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SEPTEMBER 7, 1964

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THE WEEKLY OF SPACE SYSTEMS ENGINEERING

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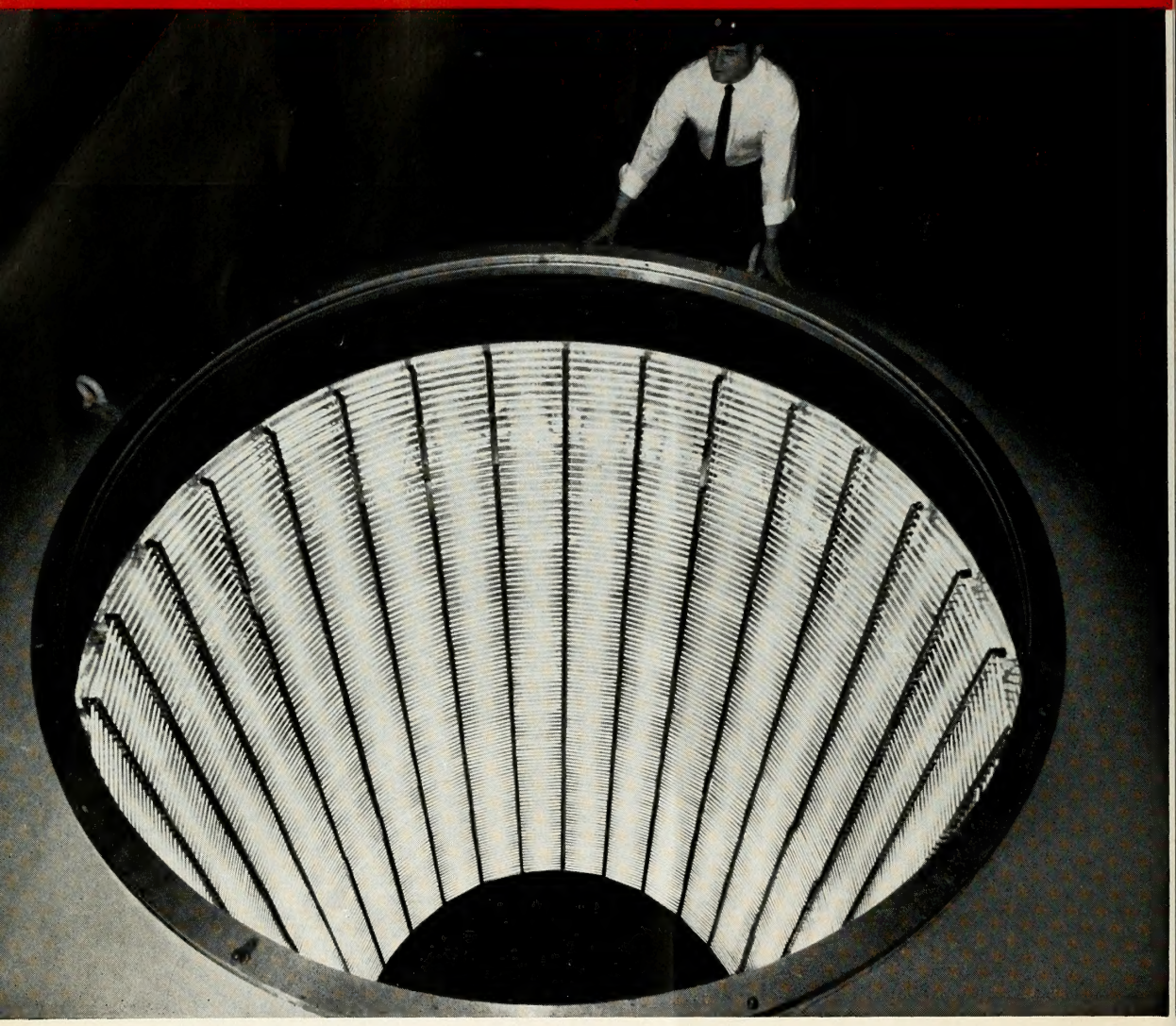
Surveyor Nose Fairing for Centaur

New Antitank/Assault Weapon Okaye

Vela Sensors Placed Near Aleutians . . .

EOS Uses Surface Tension for Energy . .

Beech "Imaginuity" in TESTING



This is where Beech puts the heat on major space age problems

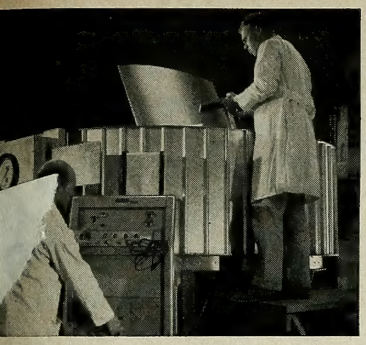
Nation's largest transient heat laboratory is a vital part of a comprehensive systems management capability

Inside this six-story building, temperature ranges from −423°F. to +1,500°F. may be achieved. 3,000 quartz lamps, programmed and operated from a remote control center, can simulate elements of standby and boost phases of flight.

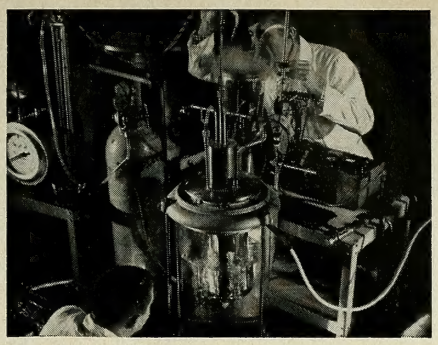
Today, this transient heat laboratory is part of the vast Beech complex that has been put to work to design, develop, manufacture and test the super-critical gas storage systems that will sustain life and supply electric power for the command module of Project Apollo. Beech has prime responsibilities for these systems as a major sub-contractor for North American.

A pioneer in Cryogenics, Beech has designed, developed and tested many tankage and propellent control systems for missiles and rockets. A constantly expanding complex of facilities coupled with highly trained and experienced personnel makes Beech a natural choice for systems management projects. In addition to this transient heat facility...

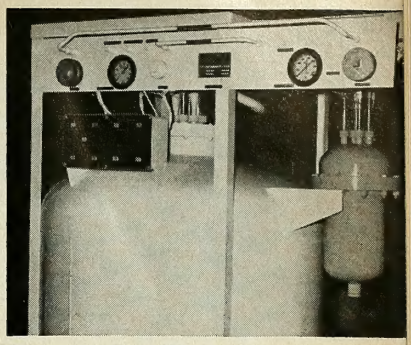
Other Beech Capabilities In Systems Management Include:



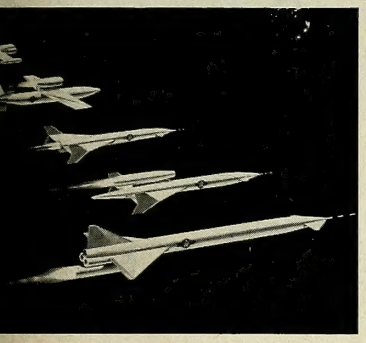
R&D...



Propulsion...



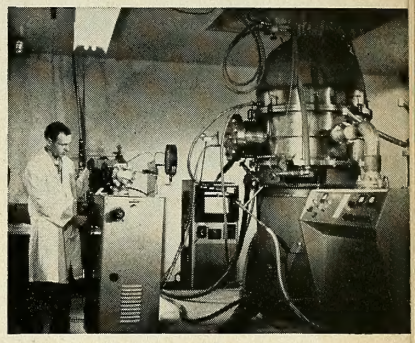
Auxiliary Power...



Missile Target Systems...



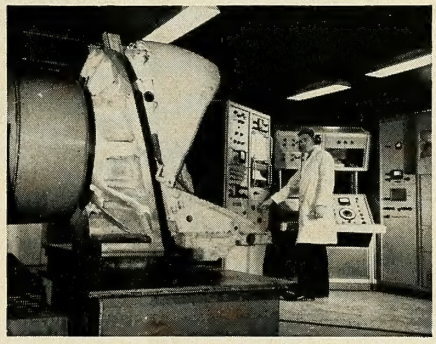
Manufacturing...



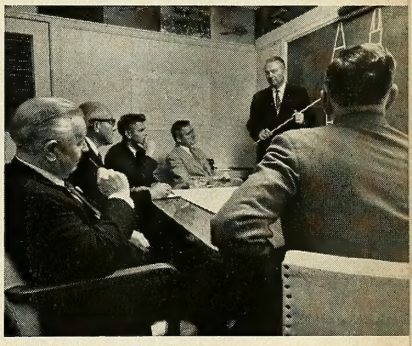
Space Simulation...



Facilities...



Complex Vibration...

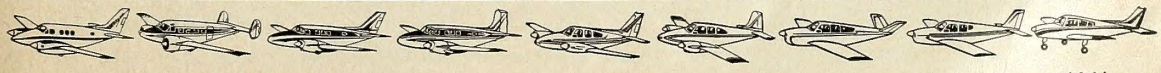


Management...

How may we help you? To discover how the proven capabilities of the Beech organization can be quickly and efficiently put to work on your project, write, wire or phone Contract Administrator, Aerospace Division, Beech Aircraft Corporation, Wichita, Kansas 67201. Beech stands ready and eager to accept complete systems management responsibility for your project right now.

Beech Aerospace Division

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missiles and rockets

THE WEEKLY OF SPACE SYSTEMS ENGINEERING

Volume 15, Number 10 September 7, 1964

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Published each Monday with the exception of the last Monday in December by American Aviation Publications, Inc., 1001 Vermont Ave., N.W., Washington, D.C. 20005. Cable Address: AMERAV.

Printed at Judd & Detweiler, Inc., Washington, D.C. Second class postage paid at Washington, D.C.

Copyright 1964, American Aviation Publications, Inc.

Subscription rates: U.S. and Possessions, Canada, and Pan American Postal Union Nations: 1 year, $5.00, 2 years $8.00, 3 years $10.00. All other foreign: 1 year $15.00, 2 years $25.00, 3 years $35.00. Air freight to Europe: 1 year $20.00, 2 years $30.00, 3 years $40.00. Single copy prices: regular issues 50 cents each; special issues $1.00 each. Subscriptions are solicited only from persons with identifiable commercial or professional interests in the missile/space industry. Subscription orders and changes of address should be referred to Circulation Fulfillment Mgr., Missiles and Rockets, 1001 Vermont Ave., N.W., Washington, D.C. 20005. Allow 4 weeks for change to become effective and enclose recent address label if possible.

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THE COVER



Surveyor nose fairing for Centaur launch vehicle undergoes tests in space environment chamber at NASA's Lewis Research Center, Cleveland. Despite Ranger VII success, results from Surveyor soft lander are vital in providing data on lunar surface hardness. See story p. 16.

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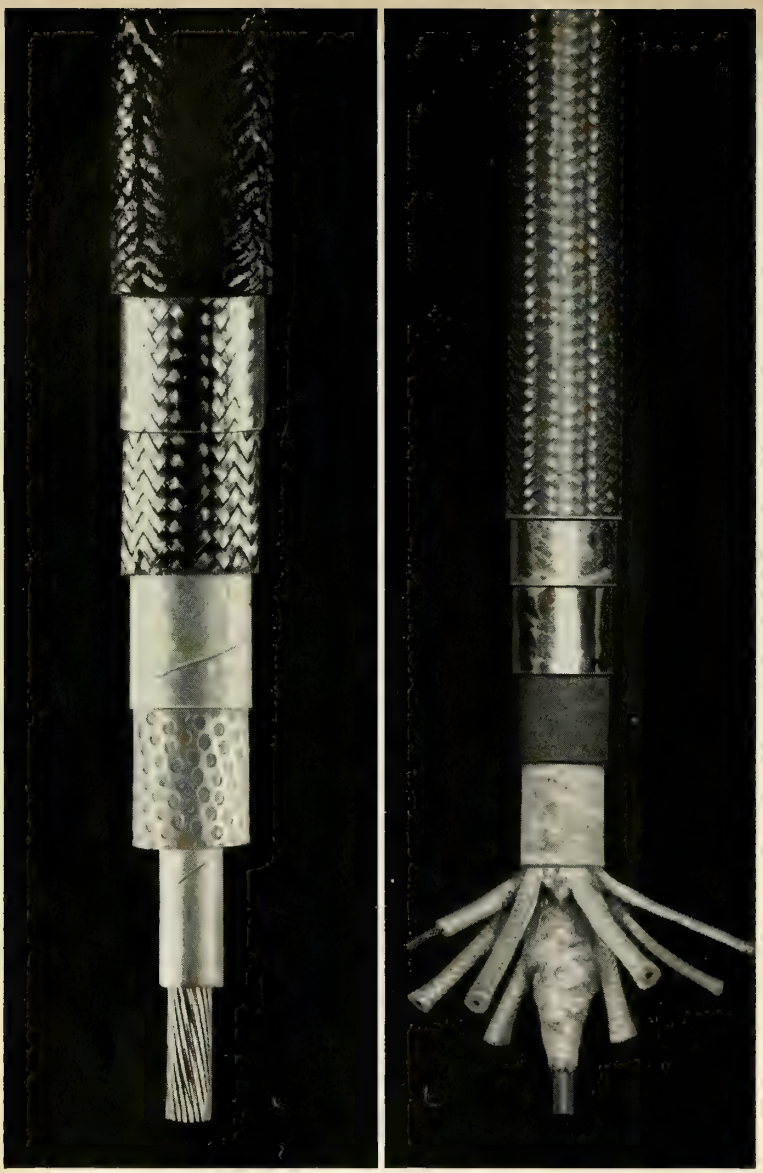
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Design is the answer to cable performance: 60,000 ft. above ground or 1200 ft. below.

Wires and cables are engineered products at Rockbestos. Like the cables above for example.

The flexible coaxial cable at left was designed to function at altitudes up to 60,000 feet. Rated 1500 watts cw at 1 Gc, it has an improved "semi-solid" Teflon dielectric core, maintains its dimensional stability at temperatures from −67°F. to 203°F.

The "Down-hole" cable at right was designed for water-tight service 1200 feet below ground and for resistance to an intermittent temperature of 1100°F. Fourteen different materials are used in this cable's insulation and jacket to provide the required physical and electrical properties.

These are only a few of the unique constructions designed and produced by Rockbestos. For total cable design capability, or for many "off-the-shelf" wires and cables which may solve your problem, call or write:

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letters

Busy and Optimistic

To the Editor:

Congratulations on your Aug. 24 editorial ("No Tears, No Sorrow").

It took your good pen to put the record straight. We are optimistic. We are busy. In many ways, just too busy to listen to the ever-present purveyors of gloom and doom.

I particularly liked your reference to the aerospace industry as "the nation's most vigorous and spirited industry." It got that way by frequently pacing, often creating, and always keeping abreast of the most advanced scientific and engineering disciplines. Add to these dedication and hard work, and your reference will stand the test of time.

Jim Riehman
TRW Space Technology Laboratories
Redondo Beach, Calif.

Snow and Cosmonauts

To the Editor:

In your Aug. 10 COUNTDOWN, it is mentioned that intelligence sources "anticipate another Soviet manned space launch before the year is out." I believe there is reason to expect that if such a flight is to occur this year, it will have to happen within the next month if the Russians continue their recovery practice of landing in Russia.

It seems to me that a consideration of the severe winters typically associated with Russia leads to an exclusion of the winter months as desirable times for the landing of manned spacecraft within the country. Neither parachuting into a Russian blizzard nor disappearing with the spacecraft into a large snowbank to await rescue appears to be a reasonable risk to present to returning space crews.

Considering the six previous *Vostok* (manned) flights, we find all of them occurring between April and August over a period of three years. A similar pattern exists for all of the dog-carrying *Sputniks* that were recovered; they occurred between March and August.

Thus, on the basis of the above rationale and evidence, if there is no launching this year by October, say, of a Russian manned space vehicle, we should expect none until next March, unless something new has been added to their landing technique. (This also assumes they are not ready to "spend the winter" in space.)

Given this restriction on landing peiods within Russia, and given Khrushchev's flair for international showmanship, would it be very surprising to see, some winter, a launching from Russia of a manned space vehicle which returns to Earth to land in some warm, friendly country well-equipped with radars and communication equipment—say Cuba?

Earl L. Fox
Silver Spring, Md.



One of the traditional complaints of engineers has been their isolation from top management. Not so at Grumman, here the interaction is complete. Engineer advice, technical and business-wise, receive a willing management ear. Communication at Grumman is a two way street as a result. Living, breathing engineering, the Grumman engineer rubs more than elbows with the people who know the problems of the program, the value of the fresh approach, the open mind and the radical solution.

Being "insider", closely allied with a management that has an *active* interest in your project, is one of the real advantages of working at Grumman. Engineers and scientists with aversion to "compartmentalization" and a liking for healthy two-way communication, will find their element at Grumman. If you are qualified, why not talk to us about the following specific opportunities.

Component Parts Engineers—BSEE preferred plus experience in electronic component part evaluation and applications of semiconductor devices and other electronic components. Responsibilities will include part selection, determination of part reliability requirements, establishing deratings and establishing test and procurement specifications.

Senior Heat Transfer Engineers — BS or MS with minimum of 5 years training and experience in structural heat transfer analysis is required. Will develop IBM programs and other analytical tools as needed to handle complicated configuration and end condition for space vehicle structures and propulsion systems. Must be capable of determining temperature distributions and recommended heat transfer configurations for initial structural designs and the detailed analyses, and test verification work to complete the design.

Temperature Control Engineers — BS or MS and 2 years experience to handle space vehicle temperature control system analysis. Should have background in radiative heat exchange and thermal coatings as applied to passive and active temperature control systems.

Fluid Mechanics Engineers — BS in AE or ME with 2 or more years experience in internal aerodynamics, duct pressure drop analyses or compressible fluid flow. Familiarity with aircraft or spacecraft propulsion systems desirable.

Propulsion System Analysts — BS or MS with a minimum of 3 years experience in rocket propulsion analysis and system simulation, using analog techniques. A good knowledge of liquid rocket feed systems, component characteristics, dynamic interactions, and vibration effects, is very desirable. Will be responsible for the development, test, and utilization of liquid rockets in manned space vehicles.

Cryogenic Engineers—BS in Engineering; experienced in analysis, design, development, testing, or cryogenic gas storage, supply, temperature, and pressure control systems.

Rocket System Performance Analysts — Degree in Engineering, Physics or Chemistry with a minimum of 3 years experience in Liquid Rocket Development, test and analysis. Knowledge of small pulsed rocket engines and pressure fed propellant systems is very desirable.

Cryogenic System Test Engineers—ME, ChE, conduct test programs on space power generation and supercritical cryogenic H2 and O2 storage systems. Must have experience with cryogenic system operation and test, and be capable of writing test plans and reports, specifying instrumentation, and defining test set-ups, test jigs and facility requirements.

Environmental Control and Life Support Engineers—BS in engineering; experienced in analysis, design, development, installation, testing, liaison with manufacturing, customer and vendors of atmosphere conditioning systems for aerospace cabin, pressure suit and equipment. Responsibilities will include proposal preparation, establishing system configuration, testing, installation.

Environmental Control and Life Support Test Engineers—Experienced in system testing-development, qualification, functional preflight. Should be capable of writing test plans and reports. Must be familiar with instrumentation requirements, laboratory equipment. Manned testing experience desirable.

Fuel Cell Test Engineers—ME, ChE, conduct test engineers on space power generation and fuel cell systems. Must have experience with fuel cell operation and test and be capable of writing test plans and reports, specifying instrumentation, and defining test set-ups, test jigs and facility requirements.

Space Power Plant Design Engineers—BS in engineering with experience in design of liquid rocket motors, and/or space power supply (including nuclear) and associated systems. Duties include conception and design of storable and cryogenic bi-propellant rocket systems and space systems.

To arrange an immediate interview,
SEND RESUME to
Mr. P. M. Van Putten,
Manager Engineering Employment,
Dept. GR-86

See next week's issue for additional professional opportunities.

GRUMMAN

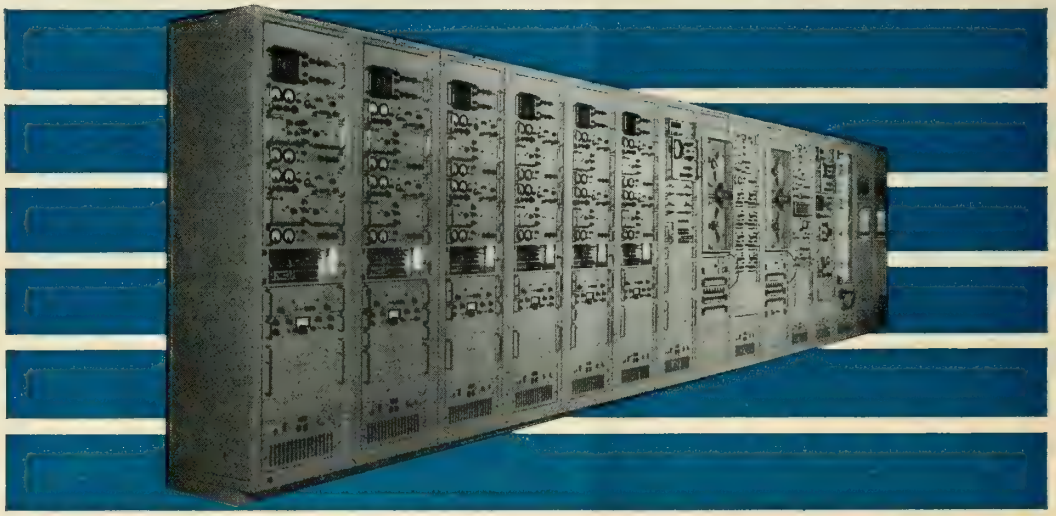
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ON JULY 27th 1964 THE AIR FORCE ACQUIRED AN ADVANCED TELEMETRY CAPABILITY



On that date, the Air Force received a completely integrated and self-sufficient predetection telemetry receiving and recording system capable of handling as many as twelve simultaneous telemetry signals of any known or projected telemetry format. The system will now undergo 60 days of exhaustive acceptance testing.

The new system, first of its kind ever designed and successfully factory tested, was developed and manufactured by Defense Electronics, Inc. It is expected to set the standard for years to come in space data acquisition facilities.

DEI developed and built more than 60 per cent of the equipment in the new system exclusively for the project. Successful completion of the unit was due largely to the perfection of new and improved techniques by DEI, including:

- Frequency-translation methods, enabling recording and reproduction of high bit-rate PCM and other wide bandwidth signals with minimum distortion.
- A diversity reception concept enabling optimum combination of telemetry data from diversity antenna systems without introduction of undesirable by-products and without need for special phase correction.
- A wide-band FM recording method, giving true DC to 500-kc bandwidth recordings.

Delivery of this initial "pre-d" telemetry system will be followed by shipment of three additional systems a month from DEI. Within less than a year, 19 fully-operational DEI systems are scheduled to go on the line at U.S. missile tracking sites on the Air Force Eastern Test Range.

Defense Electronics, Inc.
Rockville, Maryland

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The Countdown

WASHINGTON

Ocean Surveillance System Feasible

Navy is actively investigating the possibility of a space-borne radar system for ocean surveillance. Previous studies were not encouraging because of excessive weight and power requirements for conventional radar techniques. Now, however, the Navy—citing "technological advances"—feels that such a system is indeed practicable.

AF Developing Antitank Mines

Air Force's air commando group at Eglin AFB is funding work at Ordnance Div. of Honeywell, Inc. in the development of air-to-surface land mines. These weapons, launched from low-flying planes, would be used to slow an enemy advance, cut off retreat, or channel enemy armor and personnel into bottlenecks defended by friendly forces.

Senators Claim Booster Credit . . .

Senate Space Committee is pointing with some pride to steps taken by NASA and Dept. of Defense to coordinate their booster programs. Committee spokesmen say that although they apparently won't be able to get together all the witnesses required for hearings this year, the expectation of hearings has sparked the agencies to move in the right direction.

. . . And House Group Eyes Aerospace Corp.

The House Armed Services Investigations Subcommittee chaired by Rep. Porter Hardy (D-Va.) is taking dead aim on Aerospace Corp., the Air Force-sponsored non-profit organization. Aerospace is working hard to cooperate with the 10 subcommittee investigators conducting a preliminary probe of its contracting and accounting records. Hardy, however, appears unchanged in his opposition to the corporation. Findings will be presented in hearings late this fall or early next year.

Agena Included in T-IIIX Study

Air Force has awarded a $450,000 contract to the Martin Co.'s Denver Div. for a study of a *Titan III-X* vehicle with an *Agena* upper stage. Study is to be performed over the period of Aug. 14-Oct. 30.

RADC Pulling Comet Work Together

Project Comet—Rome Air Development Command's program to determine the concepts, technical disciplines and feasibility of radiation weapons—has reached the point where a Technical Development Requirement can be formulated. Comet—an acronym for Coherent Electromagnetic Energy Transmission—is also known as Project 5561. It's hoped that the TDR will highlight the remaining problem areas in the achievement of coherent radiation weapons.

INDUSTRY

Boeing Investigating Guidance Hardening

Ballistic Systems Div. has extended a contract to the Boeing Co. and modified work specifications in a program to provide radiation of "selected ballistic missile guidance systems." Presumably, both the *Minuteman I* and *II* would be included if the studies prove hardening is feasible. Goal presumably would be to protect the missile from radiation environment during launch.

Phoenix Proceeds According to Plan

Major milestone in Hughes Aircraft Co.'s *Phoenix* missile system development was reached precisely on schedule recently when key components for the G-1 working breadboard model were delivered 18 months after the start of initial design. First units turned over include missile infrared seeker head, radome and servo-electronics package, autopilot unit and five major electronics packages. Hughes has also completed the prototype power subsystem for the AWG-9 airborne missile control system; delivered the first of the MAU-48A launchers, which is currently undergoing tests; and just last week presented the first missile test station for Navy acceptance.

Extended Pioneer vs. Advanced Pioneer

Studies by TRW Space Technology Laboratories have shown that an *Atlas-Fire* booster probably could put *Pioneer* within 0.5 au of the Sun. Implementation of this extended *Pioneer* would weaken the chances of *Advanced Pioneer* becoming an approved program in 1967. Modifications needed for the *Pioneer* spacecraft would be relatively minor changes in the on-board communications system, but the 210-ft. dish at Goldstone DSIF would have to be used at long ranges. To yield results of added scientific value, *Advanced Pioneer* would have to go closer to the Sun—probably 0.3 to 0.1 au. It would thus become a solar probe. General Electric is currently evaluating the *Advanced Pioneer* mission in more detail under a three-month contract from NASA's Ames Research Center. This may result in new emphasis on the value of an outward mission to the orbit of Jupiter.

X-ray Hazard on Moon?

Possibility that the greatest hazard to lunar astronauts may be secondary X-rays excited by solar radiation is focusing increasing attention on the lunar magnetosphere. Its presence or absence will be established by the *Anchored IMP* (a lunar-orbiting spacecraft), which will carry two magnetometers and an MIT plasma probe.

MOL—The Hard Way

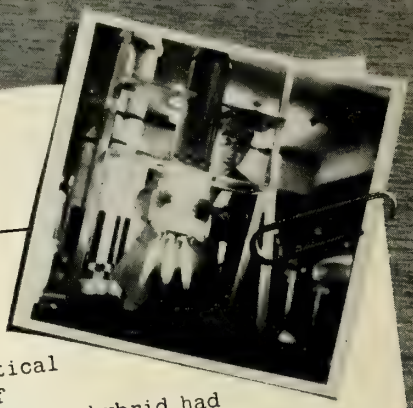
Industry sources continue to be extremely pessimistic about the future of the Air Force's *Manned Orbiting Laboratory (MOL)* program. They are concerned that it may stay in relative limbo until the U.S. is forced to turn it into a crash program. "I feel it may be quite likely that it will drag until we suddenly find the Russians already up there," one top industry source told M/R. "Then *MOL* is going to cost a great deal more than it would if it were moving along at a good pace now."

INTERNATIONAL

Anglo-French Missile Conceived

Britain and France may sign this week an agreement on joint development of a new nuclear air-launched missile for use in TSR-2 and Mirage IV aircraft in strategic roles. Development costs are estimated at almost $300 million. Contractors are Hawker Siddeley Dynamics and Engins Matra. Guidance is expected to be television. Britain's Labor Party opposition has attacked the deal on grounds that it is improper for the government to commit this kind of money so close to the general elections, now expected in mid-October.

Are advanced propulsion methods your special concern?



SUBJECT: HYBRID ENGINES

Company: United Technology Center

In 1959, UTC initiated a company-funded program aimed at developing a truly practical hybrid engine. Because of a basic lack of understanding of its combustion phenomena, the hybrid had never been anything more than a laboratory curiosity.

UTC demonstrated the feasibility of the hybrid. And as a result, the Advanced Research Projects Agency, Air Force, and the Navy funded additional r & d efforts by UTC.

Now, after four years of intensive research, the hybrid is ready for full-scale development.

NASA has awarded contracts to UTC to investigate hybrids for two different applications. Hybrid systems twice as powerful as any yet developed will be used to test solid propellant systems components. And UTC will demonstrate the feasibility of a hybrid hover engine capable of being stopped and restarted and throttled from 250 to 2,000 pounds of thrust.

More important is the relationship of hybrids to other complete propulsion systems. Recent detailed studies have now shown that even for the most stringent requirements of volume and weight-limited air-launched missiles, hybrids can produce substantially greater total performance than most storeable systems. And this performance is combined with highly significant advantages of safety, operational flexibility and economy.

Further applications are virtually unlimited: back-pack propulsion units; multimillion-pound launch vehicles; primary propulsion or attitude control for missiles and long-duration space missions.

In short: UTC has added a new and practical dimension in rocket propulsion capability.

For complete details, write UTC, Sunnyvale, California.

UTC United Technology Center

DIVISION OF UNITED AIRCRAFT CORPORATION

UA

Lewis Gets 260-in. Solid

NASA solid propulsion officials are showing more confidence in the future of the agency's 260-in. solid rocket program based on its assignment to the Lewis Research Center, Cleveland, Ohio. The program will be directed by James Kramer, who is organizing a technical staff in preparation for the final turnover of the program from the Air Force to NASA beginning with Fiscal Year 1966.

Kramer now is in the general technology area of Lewis' Chemical Rocket Systems Div., which also manages the M-1 advanced liquid hydrogen-liquid oxygen engine program. The solid effort will be concentrated in a new branch of that division.

Robert A. Wasel, Advanced Research and Technology solids program manager, outlining the current schedule of the 260-in. program, said the first round of test firings of the half-length demonstration engines is scheduled for next March or April with a second round scheduled for June or July. The engines are now under development by Thiokol Chemical Corp. at Brunswick, Ga., and Aerojet-General Corp. at Dade County, Fla.

The second phase, as conceived some two years ago when the Air Force first funded the program, is to select one contractor for a pair of test firings of a full-length 260-in. motor capable of delivering some 7.5 million lbs. of thrust.

Kiwi Reactor Tests Completed

Flushed from the successful eight-minute run of the Kiwi-B4E full temperature test August 28, Harold Finger, manager of the AEC-NASA Nuclear Propulsion Office, predicted the possibility of a nuclear stage flying in the early 1970's, with operational status achieved by 1975.

The full-power and -temperature run of the Kiwi-B4E lasted as long as the hydrogen fuel supply and marked the third major test of the nuclear rocket concept.

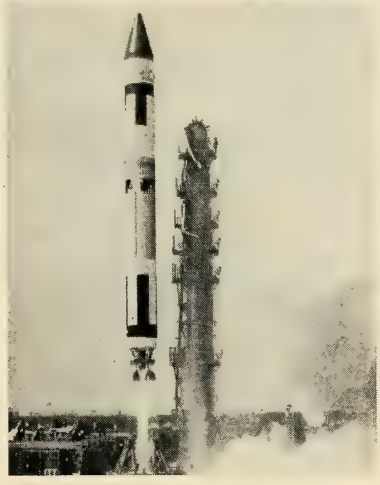
The Los Alamos Scientific Lab will now proceed with the third phase of the nuclear rocket program —the Phoebus high-power reactor. This involves at least three or four years of design, applied research and fabrication work before a reactor is ready for tests.

Information derived from the disassembling of Kiwi-B4E will be fed into the NERVA program—the second phase of the nuclear rocket effort. A hot test of the NERVA reactor is scheduled for early next month using the Westinghouse Astronuclear reactor.

Titan III-A Valve Malfunctioned

Malfunction of an onboard helium pressure valve shortened the burn time of the *Titan III-A* Transtage from a programmed 406 seconds to about 391 seconds. The end result was that the initial shot of the *Titan III-A* from Cape Kennedy Sept. 1 fell slightly short of its mission to orbit 3,750 lbs. of payload.

The valve malfunction is a "quick-look" diagnosis according to Manned Space Systems chief Brig. Gen. Joseph Bleymaier, but hard information will be obtained through malfunction duplication in static tests by Aerojet-General, developers of the Transtage. Bleymaier added that



such a pressurization loss would have resulted in loss of fuel to the system, but it was not known if the cause of failure was mechanical or electrical in nature.

The Air Force Systems Command official added that "getting orbit would have been frosting the cake." All primary and most secondary objectives were met. The flight was delayed by Hurricane Cleo and subsequent holds were caused by a series of minor problems including replacement of a faulty fuel propellant pressure regulator. This may not have been associated with the third stage.

In WESCON's Wake

LOS ANGELES—Preliminary design definition phase on the Block II version of the *Apollo* Command and Service Modules will be completed this month, NASA officials from the Manned Spacecraft Center said at the Western Electronics Show and Convention here. The first complete Block II spacecraft should become available by mid-1967. The craft will be flight-tested aboard *Saturn IB* launch vehicles initially.

It was also stated at an Aug. 28 NASA press conference at the WESCON meeting that current space agency launch plans call for an initial attempt at a manned *Apollo* Earth-orbital flight aboard the *Saturn IB* in mid-1966 at the earliest.

Officials said the *Apollo* Block II redesign would be equivalent to about a 10-15% change in spacecraft design from the initial version. Primary changes will include the addition of shock-absorbing and locking mechanisms in the front-end docking structure of the Command Module, improved electronic packaging to reduce problems imposed by humidity levels within the spacecraft and some aerodynamic cleaning up in the heat-shield area, which will involve removal of some small antenna structure.

Commenting upon the photographs taken by *Ranger VII*, NASA officials said that 90% of the lunar surface area covered in the final pictures would be suitable for a lunar landing and were well within the terrain slope angles under which Lunar Excursion Module design is proceeding. They also indicated that this fact could lead to relaxed requirements for lunar surface transportation systems under consideration.

Shots of the Week

NASA used a *Thor-Agena B* rocket combination to boost the *Nimbus I* weather satellite into orbit Aug. 28 from Vandenberg AFB, Calif. The intended 575-mi. circular orbit was not attained, but the satellite was providing satisfactory protographs from its elliptical orbit (see story, p. 15).

● The Air Force's hurricane-threatened *Titan III-A* was launched Sept. 1, four days after it was scheduled. First two stages of the vehicle functioned perfectly, but the premature shutdown of its Transtage

engine prevented the payload from achieving orbit (see item, p. 11). An Aug. 31 launch was scrubbed 3 seconds before liftoff because of minor technical problems.

● NASA test pilot Jack McKay flew the *X-15* rocket plane to 87,000 ft. at 3,716 mph Sept. 27 in a test to determine if a rippled fuselage causes less friction heating than the craft's conventional smooth skin.

ATS Experiments Sought

NASA is seeking more proposals for experiments to fly on its *Advanced Technological Satellites.*

Proposals already picked are in the areas of meteorology, communications, gravity gradient stabilization, scientific environmental measurement and mechanically de-spun communications antennas.

As described in a previous letter to the scientific community by Dr. Homer E. Newell, associate administrator in charge of space science and applications, the experiment package constraints are maximum weight of 25 lbs., volume of 18 x 11 x 8 in., maximum power of 25 watts and minimum radio frequency interference. Maximum impulse moment (angular momentum) from moving parts must not exceed 1×10^{-6} ft-lb.-sec. for the two synchronous gravity gradient missions.

Launches are slated for six-month intervals beginning in early 1967, according to the RFP.

All-Aluminum Sub Launched

GROTON, CONN.—Launching of the world's deepest-diving submarine, developed over the past five years at a cost of $3 million by Reynolds International, Inc., a subsidiary of Reynolds Metals Co., at Electric Boat Div. of General Dynamics here, marks a significant new step in the expanding industry and government effort toward development of very deep-diving vehicles.

The all-aluminum vessel—dubbed Aluminaut—is designed to descend to depths of 15,000 ft., far greater than any other submarine (though bathyscaphe-type vehicles have gone to greater depths), and with considerable maneuverability.

Successfully launched Sept. 2, the vehicle will begin initial sea trials off the Connecticut coast in about three weeks. It will make its first dive to 15,000 ft. off the Bahamas next spring. It descends in a level-keel attitude, although nose-down and tail-down attitudes are being studied.

While development has been performed in close cooperation with the Navy, Aluminaut has not received any Navy funds thus far. However, a company spokesman told M/R that negotiations with the Navy, believed to involve ONR and related agencies, are now going on.

Budget Cuts Hit Surveyor

Changes in the scheduling of the orbiting observatory satellites and the cancellation of two planned *Surveyor* spacecraft have been announced by NASA as a result of economies forced by Congressional budget cutting.

Administrator James E. Webb said that the $195-million reduction in the combined FY 1965 request of $5.304 billion and FY 1964 supplemental of $141 million would cause adjustments affecting launch schedules and program milestones, but that the space agency has advised the President that "we are not at this time willing to give up this goal which is so challenging. . ."

In manned spaceflight, the agency must absorb $114 million in cuts. However, Webb said that no money would be programmed from other divisions to make this up. Total request was $3,152,900,000.

Space Sciences, which asked $777,000,000 and received only 743,000,000, is absorbing those cuts by lengthening the launch schedule of the orbiting observatory satellites. In addition, no new procurement on these satellites will be carried out in FY 1965.

The office has also decided to drop plans for the last two of the Block I *Surveyor* spacecraft, leaving five 2,150-lb. *Surveyors* on the schedule. The nine 2,500-lb. Block II *Surveyors* were described as "high priority" and presumably their schedules will not be affected. The Mars '66 *Mariner* mission has also been dropped, in favor of more concentration on the 1969 mission (see p. 16).

Program and flight schedule changes in Space Sciences missions apparently will enable the agency to live with some cuts in the tracking and data acquisition category. However, a request may be made to Congress to transfer some funds to this category. NASA asked $267.9 million and received $260 million.

Cuts in Advanced Research and Technology, for which $320 million was asked and $316 million received, apparently will not affect any major programs. The same is true of technology utilization and program planning, for which $5 million was asked and $4.75 million received.

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Army Gets Antitank Go-Ahead

by James Trainor

THE ARMY has been given a go-ahead to pursue an aggressive exploratory development program for a *Medium Antitank/Assault Weapon (MAW)*. The program will involve carrying two competitive approaches to the stage of demonstration firings, after which it is anticipated a choice will be made to develop one of the two weapons.

The first approach—a wire-guided missile—will be explored by McDonnell Aircraft Corp. under a $2,718,960 cost-plus-fixed-fee contract from the Army Missile Command, Huntsville, Ala.

The second development—an in-house Missile Command effort—will take advantage of Arbalest program work done on hypervelocity missiles by the Agency and the Ballistic Research Laboratories, Aberdeen, Md. Sperry Rand Corp.'s Ford Instrument Co. Div., if negotiations currently in progress are successful, will provide exploratory development and test of a two-degree-of-freedom free-rotor gyroscope for the in-house missile.

● **Moment of truth**—By August or September of 1965, Defense officials expect to be in a position to fire the two missiles off against each other and proceed with full-scale development of the more promising version.

A *Medium Antitank/Assault Weapon* would fill the gap between the *M-72* light antitank weapon with a range of 500-600 yards and *TOW* (*Tube-launched, Optically tracked, Wire-guided*), which is being developed to reach out to ranges of 2,000 yards. Nominally then, the range of *MAW* would be 500-1,500 yards.

Approval for the *MAW* exploratory development program was given during the week of Aug. 10. The previous week, MISSILES AND ROCKETS had strongly criticized the pace of the Army's antitank development effort (M/R, Aug. 3, p. 10).

● **McDonnell effort**—After evaluation of a number of proposals from industry, the Army selected McDonnell's wire-guided missile as the best approach to the *MAW* requirements. The company has proposed essentially a shoulder-fired *TOW*, according to official sources.

The missile and launcher would be lighter than the 160-lb. *TOW* launcher and missile, but would presumably use the same optical system in which the gunner sights on a target and as he tracks it, a linkage feeds correction commands to the missile in flight.

TOW uses a small motor to eject the missile from the launch tube and a second to sustain the missile in flight. It is likely that the same approach would be used in the McDonnell *MAW*.

● **Missile Command approach**—In the Missile Command version of *MAW*, there is no requirement for guidance after launch. It, too, is a shoulder-fired weapon. The use of high-energy propellants has been made possible through development of a means to control the hypervelocity missile. While some Army officials advocated use of high-burning-rate propellants, control of the missile in flight had always been a problem.

Directional control of the missile apparently will be achieved through the use of the two-degree-of-freedom, free-rotor gyroscope. Such a system would be constrained around the roll axis and would sense deviations in the pitch and yaw axes. Translation of these deviations in the missile trajectory into missile corrections could be achieved through the use of a circular ring in the nozzle, which, functioning like a jet tab, would divert the stream in the desired direction.

Burning rates of approximately one-half inch per second were expected from the Arbalest program and would be applicable to *MAW*. Some 40 test rounds were delivered to the Army by Douglas Aircraft Co. for firing at Aberdeen Proving Ground to investigate the potential of high-burning-rate propellants for high-acceleration, hypervelocity missiles. The results of this program are said to have been extremely good.

MAW has been carried on the Army's books as a requirement for more than three years. However, the combination of *TOW* development, which relieved the pressure for a medium weapon, and a disagreement between the Army's Combat Developments Command and the Material Command over the characteristics of such a weapon, has delayed its development until the recent action. ■

Pacific Polaris Fleet Readied

SUBMARINE SQUADRON 15—the Pacific Ocean arm of the Fleet Ballistic Missile deterrent force—will begin operations around the end of this calendar year with the deployment of the USS Tecumseh (SSBN 628) and the USS Daniel Boone (SSBN 629) to the area. Pearl Harbor, Hawaii, will be the squadron's home base.

By mid-1965, two more *Polaris* submarines—the USS Ulysses S. Grant (SSBN 631) and the USS Stonewall Jackson (SSBN 634)—will be on station in the Pacific. The squadron will be rounded out with three more submarines before June, 1967. Although these submarines have not been designated, the most likely candidates for two of the berths are the USS Kamehameha (SSBN 642) and the USS Mariano G. Vallejo (SSBN 658).

All of the submarines in the Pacific squadron will be armed with the 2,500-n.mi. *A-3* missile.

The submarine tender Proteus will provide routine maintenance and replenishment at the forward resupply site at Guam. In addition to Proteus, a floating drydock will form part of the *Polaris* facilities at Guam.

Navy Secretary Paul H. Nitze will dedicate the *Polaris* missile assembly facility at the Naval Ammunition Depot, Bangor, Wash., Sept. 11. This facility will receive, assemble, inspect, check out and load *Polaris* missiles into the submarines. The FBM subs themselves will be overhauled at the Puget Sound Naval Shipyard, Bremerton, Wash.

Only 70% coverage . . .

Nimbus Suffers from Elliptical Orbit

But officials still are optimistic of six-month orbit; later launches in program will carry advanced sensor systems

THE SPACE AGENCY still hopes to achieve *Nimbus I's* designed objective of six months in orbit, even though the satellite went into an elliptical rather than the planned circular path.

The actual orbit—with an apogee of 579 mi. and perigee of 263 mi., instead of the desired 575-mi. circular route—also means that the weather satellite launched from Vandenberg AFB, Calif., on Aug. 28 is covering only 70% of the Earth's surface with its advanced vidicon camera system (AVCS) and high-resolution infrared radiometer (HRIR).

However, Harry Press of the *Nimbus* project office told a briefing at the Goddard Space Flight Center last week that he still hopes the 830-lb. satellite will stay up six months, and that there are some advantages in the elliptical orbit.

He noted that the lower-than-planned perigee gives higher resolution for the AVCS—from a half-mile to a quarter-mile. Furthermore, he said, the orbit keeps *Nimbus I* outside the radiation belts, providing better operation of the HRIR sensor than would be possible otherwise.

Nimbus program officials say that when the satellite is operating at full capacity it will supply 100 AVCS pictures during each of the average 12 orbits—totalling 1,200 pictures a day—and 10 strips of HRIR nighttime pictures.

Dr. Harry Goet, director of GSFC, said he hoped to launch the remaining three satellites in the program. He said, however, there was little point in launching an identical satellite in the next shot.

Nimbus II is due for launch within a year; a third, more advanced "B" model is to follow. GSFC hopes to add advanced sensor systems to these satellites so that, unlike *Nimbus I* and all earlier weather satellites, they will be able to do more than map cloud cover.

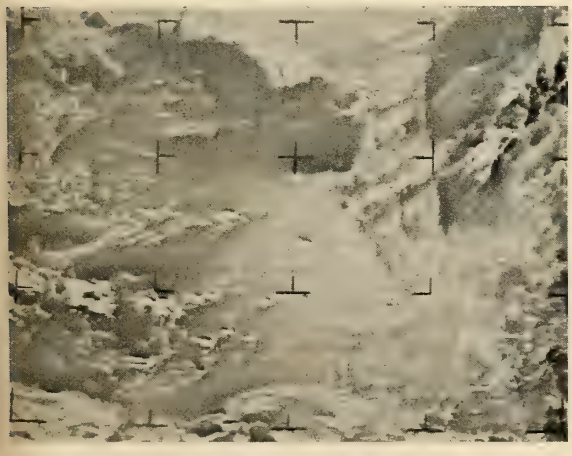
Nimbus I's failure to achieve desired orbit was caused when the *Agena* second stage burned only 0.84 sec., instead of the 3.8 sec. expected. Press said this will pose "substantial" problems. Perhaps the most serious is that the control system was designed for a circular orbit, and the gas in the jets may have to be expended more quickly than anticipated. Also, there will be some gaps in the reception of pictures.

Instead of the 13.9 average orbits per day planned for, Goddard is getting 14.7; however, the number of orbits in which data are not received each day is ranging from two to seven, rather than the hoped-for two to three.

The infrared pictures were the first ever published of the Earth's cloud cover photographed at night. The HRIR system takes a strip of pictures about 1,500 mi. wide and covering half of the Earth's surface from north to south in each transmission. One strip taken shows cloud cover from Manchuria to Antarctica.

For the future *Nimbus* launches, GFSC scientists say they plan to use devices such as spectrometers and microwave radiometers to gather temperature profiles. In addition, to gather data on pressure and winds, receivers would be installed in the satellites to pick up signals from instrumented buoys and automatic stations in remote locations.

All these data would be fed into a computer, where they would be compared with mathematical models to provide rapid readout of weather conditions around the world. ■





EXCEPTIONAL quality of Nimbus transmission shows in these pictures. LEFT: APT shot from 515-mi. altitude picks up Cuba, as well as four U.S. states. RIGHT: Infrared picture taken near midnight from 280 mi. clearly shows Caspian and Aral Seas in western Russia. Near left center is Volga River.

Surveyor Must Settle Doubts on Lunar Surface

by Hal Taylor

DATA ON THE STRENGTH of the lunar surface and whether it will support a manned spacecraft will not be known until 1966 at the earliest.

NASA experimenters, after detailed study of *Ranger VII's* photos of the Moon (see p. 18), reaffirmed that the Earth's satellite will provide a suitable smooth landing site for Project *Apollo*.

Dr. Gerard Kuiper of the University of Arizona, Dr. Eugene Shoemaker of the U.S. Geological Survey and Dr. Harold E. Urey of the University of California declared, however, that a definite answer to the age-old question of the strength and make-up of the lunar surface will not be known until instruments are landed on the Moon.

Surveyor 4, the first U.S. spacecraft to provide that capability, will not be launched until the third or fourth quarter of 1966, NASA officials say. Since technical problems with *Surveyor's* landing gear still have not been solved, slippage into 1967 is a possibility. If the slippage does occur, it could prove to be critical to achieving the first U.S. manned lunar landing—still officially scheduled for late 1970.

Comments of the *Ranger* experimenters at an Aug. 28 press conference in Washington revealed that despite the excellence of the *Ranger* photos, many of the ancient controversies surrounding the Moon still remain.

Although both said that real proof would have to be obtained by *Surveyor*, both Kuiper and Shoemaker held that the large marias or seas on the lunar surface are lava beds formed ages ago and astronauts will sink less than a foot when stepping on the surface.

● **Demurrer**—Urey, in a paper read for him at the conference, sharply dissented with that view.

"The question of whether the lunar maria consists of lava or finely divided material is in my opinion unanswered by these pictures. I have seen nothing that definitely convinces me to either point of view," he said.

He noted that there are certain features which he could interpret as due to dust or finely divided material and other features that suggest possible lava-like structures.

● **Rocks and craters**—Another area of partial disagreement is the absence of evidence of large rocks.

Kuiper and Shoemaker said this indicated considerable erosion by cosmic dust and solar particles.

They disagreed, however, on the magnitude of the wearing-away process.

Kuiper said he would place the process at about five feet.

Shoemaker declared that the erosion rate was more like 50 ft. He pointed out, however, that even a five-foot erosion rate would remove a good deal of individual large fragments one might expect to find on the Moon. "Once you get a rock above five feet, it tends to break up on impact into smaller pieces," he said.

Kuiper said that a very important new result of the *Ranger* flight was the large number of secondary craters in the area photographed.

He said this disproves previous theories that the crater ray areas were composed of a few primary craters and a few secondary craters with a large amount of powdery material in between.

Instead, he said, the crater ray area was composed of myriad clusters of secondary craters and even a large amount of tertiary cratering.

He added, however, that in many areas there are primary craters and only a few secondary craters. These, he continued, would provide suitable landing sites because 90% of them would be free of craters.

Also touching on the Moon's flatness, Shoemaker said the final photo had a median grade of only 5 degrees and that the largest slope measured had a grade of 18 degrees.

He said that only about 10% of the area photographed had a slope greater than 15 degrees.

Another interesting observation, by Urey, concerned one crater in which craggy objects are clustered. Noting that the objects did not appear to stem from the material which created the crater, he hypothesized that they might be the tops of a subterranean mountain pushing through the surface.

● **Refinements**—Further refined results of the *Ranger* flight were also revealed at the press conference.

The space agency said that the spacecraft impact point was within six miles of the planned one and within 19 seconds of its planned arrival time.

The last picture taken showed objects down to 10 inches in size. It was taken from an altitude of 1,600 ft.

The space agency also said that new data from the *Ranger* flights has improved the accuracy of measurements of the masses of the Earth and the Moon by factors of 3 and 10 respectively. ■

New Mariner Mars Contracts Due in Month

HARDWARE FUNDING of the *Mariner* Mars 1969 spacecraft will not begin until Fiscal Year 1966.

NASA officials say Phase I of the program will begin late this year, when two to four firms will be selected for a program definition and preliminary design contract.

While the project marks the first time a missile/space firm will be selected to build a U.S. planetary spacecraft, project management will remain at Jet Propulsion Laboratory.

It has also been decided that either a regular *Atlas-Centaur* vehicle or its floxed *Atlas* counterpart will serve as the launch vehicle.

While no final agreement has been reached, it now appears the spacecraft will be sent on a Mars orbiter mission rather than a fly-by flight with a survivable capsule which it would inject into the red planet's atmosphere.

Many NASA officials now apparently agree that the orbiter would provide more scientific information.

The 1969 launch window would enable the spacecraft to get to Mars just as the wave of darkness begins in its southern hemisphere. If a minimum orbital lifetime of three months could be obtained, seasonal changes could be observed.

A final decision on the mission will not be made for about 30 days, when Avco Corp. finishes a study of the capsule lander mission. Lockheed Aircraft Corp. has already completed a study of the orbiter in flight.

Undersea Sensors Planted Near USSR

Devices developed in nuclear detection program, but ostensible role is earthquake detection; other Vela progress revealed

by Michael Getler

LOS ANGELES—Six newly developed ocean-floor-mounted seismometers, described as "research vehicles" for the Dept. of Defense nuclear-test detection project known as *Vela,* have recently been planted in the Pacific Ocean near the Aleutian Islands.

Ostensibly, the units will keep tabs on the relatively active earthquake region surrounding the Soviet's Kamchatka Peninsula and Kuril Island chain. In this area, ocean-mounted seismometers obviously could aid land-based sites in properly evaluating earthquake activity.

However, informed sources also point out that it is in the approaches to the Kamchatka region that the USSR is the most "seismically accessible, although, *unfortunately,* they do have many quakes there."

Underwater detection systems still must be clearly proven, according to experts in the field, in terms of providing additional gain over land-based systems. But they make it possible to establish stations in closer proximity to some areas than would be possible with land installations.

The U.S. program to detect clandestine nuclear tests, under direction of DOD's Advanced Research Projects Agency (ARPA), does have a charter to explore all mediums in which bombs may be exploded as well as all types of inputs which may contribute to a broad capability.

● **TI advances**—The new sensors in the Aleutians, developed by Texas Instruments, Inc., together with other new sensors developed by the Lamont Geophysical Observatory at Columbia University and at the University of California's Institute of Geophysics and Planetary Physics, are all being evaluated for possible roles in the undersea portion of *Vela.*

A series of tests using dynamite explosives is slated in the Aleutians this month to check out the instruments there and gather area data.

The TI sensor is probably the most advanced of those now being looked at for *Vela,* sources close to the project report. While perhaps the most advanced sensor work and experience in this technology has been accomplished at the Lamont Lab, TI is known to have made major inroads through major efforts in industrial design and application.

The TI seismometer is reportedly of the pop-up variety, released from its bottom mooring by an exploding squib. It is also believed to include a new recovery technique. The package consists of three transducers, low-noise parametric amplifiers, hydrophones to measure pressure fluctuations, and a new direct-recording magnetic tape unit about which scientists are known to be enthusiastic. The recorder reportedly operates at slow speed and low power continuously for 30 days, and contains highly stable tape-drive and amplifier units.

● **Two new efforts**—In other developments in the *Vela* program, Lincoln Laboratory scientist Dr. Paul Green, speaking at the recent WESCON meeting here, outlined the two new programs being undertaken by ARPA to increase the size and sensitivity of land-based nuclear detection systems.

Five seismic arrays now are in operation in the U.S., located in Oregon, Utah, Tennessee, Oklahoma, and Arizona. The largest existing complex, in Arizona's Tonto Forest, stretches across a 6-mi. area and includes 51 seismometers. (The British are believed to have built linear arrays larger than the Tonto Forest system.)

While these sites have been useful in detecting and identifying seismic activity, scientists point out that much better results could be obtained with larger arrays that are much longer than the 5-15-mile-long wavelengths of the actual seismic disturbances.

To accomplish this, ARPA has launched two projects, one of an intermediate nature and the other a totally new and more complete system.

The first of these involves extending the Tonto Forest array through use of mobile seismometer-equipped vans to about a 218-mi. linear dimension. Instrumentation for this is reported to be complete and initial experiments are said to be getting under way. While this does give the site a wider area, sources say it is not filled in with instruments in an optimum fashion. It will therefore be useful primarily for intermediate experiments.

The second system is a very-large-aperture array, 100-mi. in diameter and containing some 500 seismometers, which will be installed in the north central U.S. and be in operation by late next summer, or early fall, according to sources close to the project. Field parties are said to be surveying land areas.

Scientists say the two new projects are actually aimed more at improving detection and blast discrimination capabilities through proper use of large-aperture arrays than at merely improving individual sensors, which are already reported to be highly sensitive (sometimes a complicating noise factor).

By designing arrays several wavelengths long, the scientists hope to better suppress microseismic noise, which often obscures a signal, and also to suppress the obscuring multipath signals which arrive at the site with various time delays through any number of secondary paths from the blast area.

Using 21 of the 51 seismometers with the existing Tonto Forest array, Lincoln Lab scientists say, they can now detect a disturbance equal to a 3.5 reading on the Richter scale at a distance of about 3,000 mi.

The increase in sensitivity of the new detection system, they told M/R, should be at least proportional to the increase in the number of sensors used. Therefore, when the 500-seismometer system is completed next year it should represent about 25 times greater sensitivity than the group of instruments at Tonto Forest now used for this application, allowing measurement of 2.5 or 2.75 disturbances on the Richter scale at the same distances.

The Lincoln Lab technical design and implementation work is being done for ARPA through an AF contract from the *Vela* Seismological Center of the AF's Technical Applications Center. ■

Ocean-Based Strategic Weapons Held Neither Feasible nor Necessary Now

ALTHOUGH recommendations and conclusions of the Navy's June 6-July 24 Project Seabed Advanced Sea-Based Deterrent conference exercise are classified, two conclusions seem to be important considerations in any future sea-based deterrents:

—Deep-ocean strategic systems are not now considered either necessary or feasible and will not play a major role in military systems until costs are reduced and technical hurdles overcome, but . . .

—The advantages of mobility and concealment offered only by the ocean "are not to be thrown away lightly."

In an exclusive interview with MISSILES AND ROCKETS, Dr. John P. Craven, chief scientist for the Navy's Special Projects Office stressed that it would be "a long, long time" before it would be necessary for the Navy to use all the protection the ocean offers for hiding. He specifically divorced the Advanced Sea-Based Deterrent from deep-ocean technology.

● **Cost an obstacle**—The Monterey, Calif., conference explored not only the potential use of the sea for future deterrent systems but also probed ways in which the Navy could extend its versatility and usefulness to other parts of the strategic spectrum—particularly those that appear highly promising with respect to cost.

Through exploitation of technology, the cost of deep-ocean systems should be reduced substantially. In particular, if materials and structures problems can be solved to get applications flowing freely, costs can be reduced to a point at which the deep ocean could become attractive for military use.

Looking beyond the *Polaris B-3* time scale, the conference examined the Navy's strategic role in the 1970-1980 time period, and its mission in deep-ocean technology.

● **Conference scope**—The Seabed conference was attended by 50-100 persons, mostly from the Navy's in-house labs, plus other contributors, such as the Stanford Research Institute.

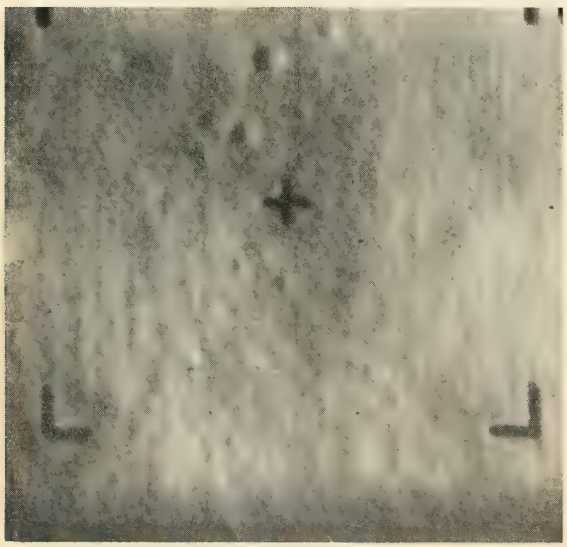
Private industry conducted briefings for the group at industry's discretion. Distinguished members of the scientific community, such as Dr. Edward Teller, director of Livermore Radiation Laboratories; Dr. Frederick Seitz, president of the National Academy of Sciences and Dr. Charles C. Lauritsen, vice-chairman of the board of trustees of Aerospace Corp. and professor of physics at California Institute of Technology, were called upon as consultants to the conference.

Four panels—Weapons, Deep-Ocean Technology, Systems and an Over-view and Review—studied the problem of advanced sea-based systems.

Among the systems studied were: untended missiles deployed in the ocean or along the littoral of the U.S. or other land areas, moored manned stations, a missile "field" tended by a mother submarine, small single-missile submersibles, and extensions of *Polaris* concepts. In fact, any idea applicable to advanced sea-basing was studied in detail, including systems based on or above the ocean's surface. ■

NASA Releases Further Ranger VII Photos

RECENTLY RELEASED Ranger VII photos are among last taken by (partial scan) series cameras before spacecraft's impact on Moon surface July 31. LEFT: Taken 0.82 sec. before impact, photo has slant angle of 7,056 ft. and lunar area shown is 277 ft. on longer side. RIGHT: Snapped 0.62 sec. before impact, this shot has slant angle of 5,317 ft. and width of 583 ft.





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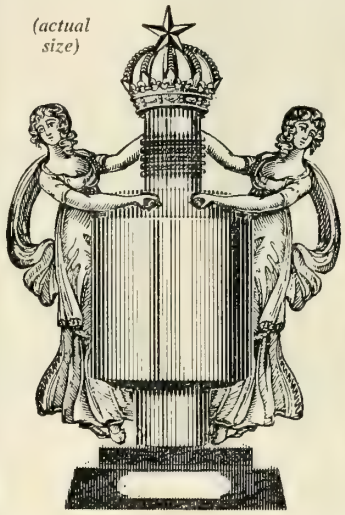
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(actual size)



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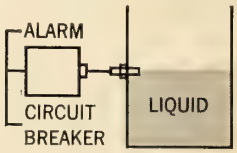
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Technical Countdown

ELECTRONICS

Systron Picked for Remote Weather Spotter

A system originally developed five years ago by Systron-Donner Corp., Concord, Calif., for retrieving weather information from satellites has been adapted for use by the U.S. Weather Bureau as an automated weather report system for ground stations. Named Systrac, it is designed for remote, unattended field stations and gathers and transmits wind speed and directions together with temperature data within 10 seconds to a central computer programmed to assemble weather reports. The first system will be installed at Las Vegas, Nev., at a cost of approximately $200,000, according to Systron-Donner. The installation consists of six field stations and four master stations over a wide area of desert previous monitored by personnel traveling from station to station to pick up recorded data.

GC Audio Waves Obtained in Crystal Studies

Thin-films of crystalline cadmium sulfide 10^{-7} to 10^{-6} in. thick are being employed by Westinghouse Electric Corp.'s Pittsburgh Research Laboratories to obtain ultrasonic waves at frequencies up to 9 gc. Further research, according to lab scientists, will soon yield frequencies to 900 gc. The piezoelectric transducers so far have avoided the tendency to brittleness of more conventional ultra-thin quartz crystals. The work, performed under an Air Force Cambridge Research Labs contract, is part of a basic study of the structure of crystalline materials, such as ruby and sapphire. The thin films are deposited directly on the materials under investigation. A short high-frequency microwave pulse is used for crystal excitation.

Miniature Time Reference Available

A Rubidium frequency Standard, the R-20, recently developed by Varian Associates is believed to be the smallest fully synthesized atomic frequency standard ever built. Applicable to both aircraft and spacecraft use, the long-term time reference is stable to one part in 10^{11} for a 1-second averaging time or one part in $5x10^{11}$ throughout a full year. Its accuracy, says Varian, is good to $\pm$ 10^{-10}. Measuring only 5x7x19 in. and weighing less than 20 lbs., the standard provides output frequencies of 5 mc, 1 mc, and 100 kc.

Laser Signal Converted to AM Beam

An optical ratio detector, consisting of two birefringent crystals several centimeters long, has been used to demonstrate conversion of microwave phase-modulated laser light to microwave amplitude-modulated light at modulation frequencies between 2 and 12 gc. The experiment, carried out at Stanford University, used the ratio detector with a helium-neon laser, a KDP phase modulator and traveling-wave phototube.

MATERIALS

Electrically Conductive Plastics Developed

A series of plastics capable of conducting electricity are entering commercial development at General Electric's Research Labs in Schenectady, N.Y. The process used to make the plastics can also control the degree of conductivity. In their presentation to a recent meeting of the American Chemical Society in Chicago, Dr. John H. Lupinski and Kenneth D. Kopple said that tests indicate the plastics can conduct electricity indefinitely without undergoing changes. While not as efficient as metal conductors, the plastics can be molded and shaped easily or applied as paint and putty.

FLOX Tests Successful

A series of tests at General Dynamics/Astronautics using a 50% by weight mixture of LOX and liquid fluorine proved that component performance characteristics observed in earlier tests with only a 30% addition of fluorine were well within the desired limits for *Atlas* flights. The increase in fluorine was necessary in the test program because boil-off from the 30% mixture can produce concentrations of gaseous fluorine in excess of 30%.

260-in. Thrust Ring Fabricated by Bethlehem

A massive 300-in.-dia. steel ring will be shipped by barge from Bethleham Steel Co.'s San Francisco shipyard to Aerojet General's Dade Div. in Florida early next month. The ring will be used in the thrust measuring device during the test firing of the 260-in.-dia. solid rocket currently being built by Aerojet-Dade. Motor thrust will be transmitted through the ring to three load cells spaced equidistant around and below the ring in the cast-cure and test firing pit.

Nuclear Fuel Recycling Lab Site Sought

A joint research and development program on advanced methods for reprocessing nuclear fuels—including the construction of a $1.7-million recycle fuels laboratory—is in progress with Dow Chemicals Co. and Westinghouse Electric Corp. A number of western sites are being studied for the lab, which will be constructed in 1965. Existing Dow and Westinghouse research facilities will also be used in the program designed to find ways of decreasing nuclear fuel costs by reprocessing the fuels. Techniques for fabricating plutonium fuel elements will be studied. A $1-million operating budget has been established for the first 17 months of the project.

SPACE MEDICINE

Immersion Tests Yield Weightlessness Data

Underwater zero-g tests in a full-scale mockup of a manned spacecraft are in the planning stage as a direct result of preliminary runs conducted by General Dynamics/Astronautics. The week-long immersion tests involved a metal iris and test subjects, but the data convinced Astronautics Div. Life Science Lab engineers a full scale mockup could supplement information obtained in parabolic aircraft flights. The tests measured the total motion of the human body in a weightless condition through an infinite number of spin axes. Other tests in the series simulated lunar and Martian gravity by varying the subject's buoyancy.

Solar Flare Simulation Studies Planned

Seven primate whole-body proton experiments in support of the space program are being planned by the Air Force School of Aerospace Medicine. Cyclatron facilities in Europe and the United States are being considered for the series, which will be conducted over a period of a year to 16 months. Seven tentative energy levels between 14 Mev and 2.3 Bev have been selected for the study, to simulate the wide energy spectrum that would be possible in different solar flare situations and with various shielding materials and designs.

Surface Tension Is Energy Source

EOS applies liquid principle to pump propellants for ion rockets; weightlessness tests indicate method is feasible

by Russell Hawkes

PASADENA, CALIF.—A method of using the surface tension of liquids as a source of energy to pump ion rocket propellants to the tank outlet in a zero-gravity or low-acceleration environment has been developed by Electro-Optical Systems, Inc.

It could also be used with lubricants or other liquids aboard spacecraft, although EOS has done no laboratory work on these applications. Surface tension pumping has become a standard part of EOS ion rocket systems under development for the Air Force and NASA. Persistent industry and government reports indicate that one of the Air Force systems will undergo a sub-orbital flight test within a very few weeks.

Propellant tank models equipped with surface tension pumping systems have been subjected to zero g for 1.85 sec. periods in free-fall drop tests at Wright-Patterson AFB, Ohio, and for 12 to 15 sec. in C-131 aircraft flying ballistic trajectories. Results indicate that the concept works, at least for the brief durations possible in these types of tests.

● **Physics of tests**—The concept is based upon the fact that wetting liquids enclosed in a tapered vessel migrate toward the narrow end because surface tension acts to minimize the free surface area and maximize the area of wetted contact surface.

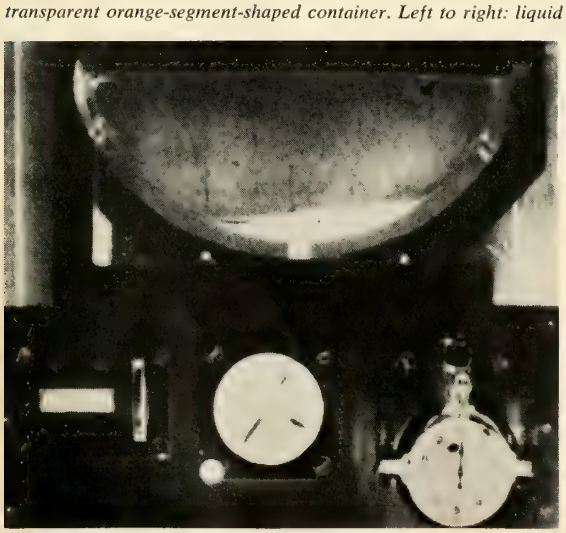
The principle has been thoroughly discussed by all technologists working on the positioning of liquids in gravity-free storage vessels. The trouble is that a long, tapering vessel is not an efficient shape for a spacecraft component.

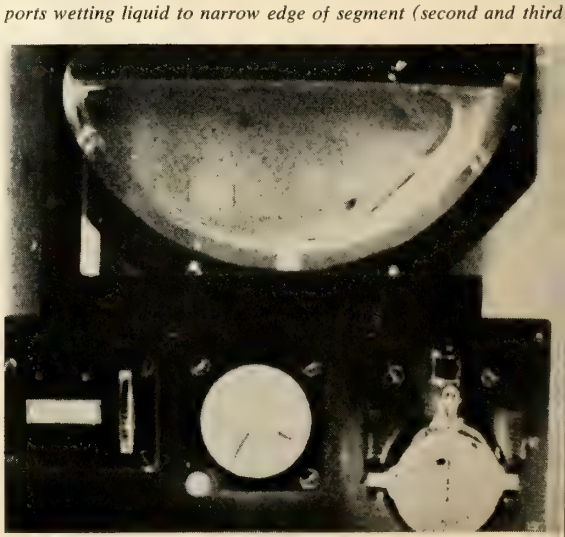
EOS manages to use a spherical tank by putting in closely spaced dividers extending radially from the centerline of the tank. The surface tension of the liquid cesium propellant moves it inward between thin converging stainless steel dividers to a porous nickel foam "wick," which soaks it up and carries it toward the ion engine by capillary action.

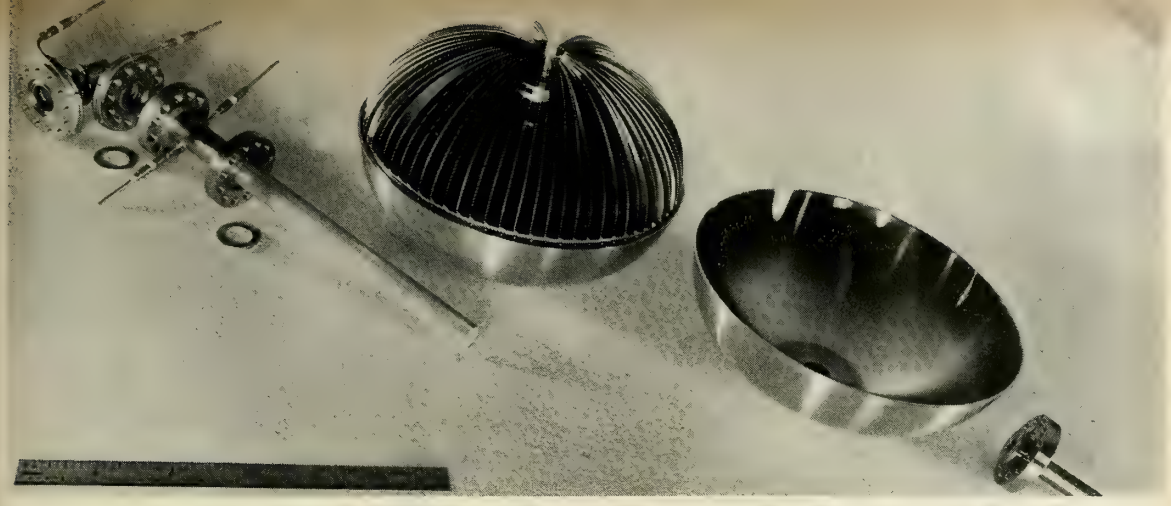
Nickel is not normally wetted by cesium, but the wick can be preconditioned by heating it to 200°C, after which cesium will continue to wet it without further heating as long as the temperature remains above the cesium freezing point. For the sake of reliability, the preconditioning can be done during propellant loading rather than in flight.

At the downstream end of the wick, a heating coil vaporizes cesium off the end of the wick, and the slightly elevated vapor pressure moves the propellant through a feed tube and into the ion emitter. As the liquid is vaporized, more seeps through the wick to

PHOTO SEQUENCE shows zero-g test of a wetting liquid in transparent orange-segment-shaped container. Left to right: liquid rests on bottom of vessel; in zero-g state, surface tension transports wetting liquid to narrow edge of segment (second and third







ION ROCKET propellant tank with top removed to show radial dividers that comprise surface tension pump. Wetting liquids are moved by their own surface tension to narrow part of each orange-segment-shaped volume. Foam nickel wick is at left.

replace it. The system works with the gas discharge type of engine being developed for NASA as well as with the contact ionization type being developed for the Air Force.

EOS engineers regard surface tension pumping as the "ultimate solution" to the problem of positioning and moving liquids where little or no gravity or acceleration exists and where very high flow rates are not required. It does not require the expenditure of on-board power and there are no moving parts.

● **Limitations**—The technique cannot be used during the boost phase of spaceflight because accelerations even less than that caused by gravity are more powerful than the surface tension effect, with the liquid settling to one side of the tank.

During high accelerations and vibrations, there is even a possibility that the liquid would be expelled through the wick and into the feed tube, where it would block the operation of the system.

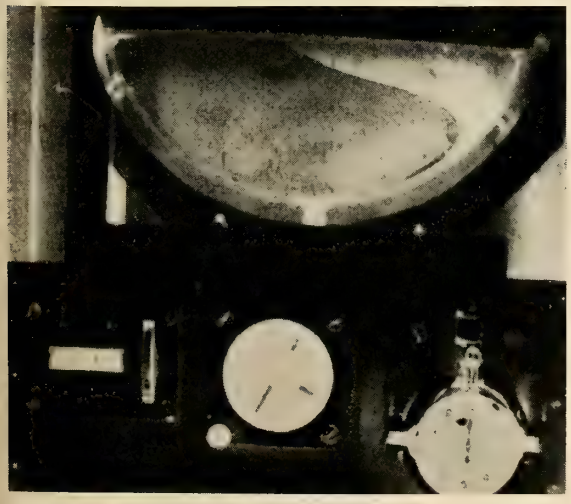
To prevent this, EOS will freeze the cesium during launch and melt it before starting the ion engine. This is not difficult, since the freezing point of cesium is 82°F and tank temperatures throughout flight will be little higher than that.

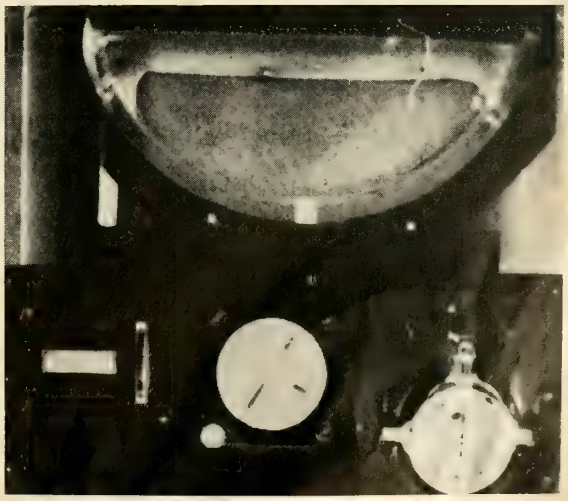
EOS engineers found the development of mechanical systems with moving parts to position propellant in zero gravity "extraordinarily difficult" because of the low-pressure environment and the corrosive nature of cesium. Such components as valves showed little promise of ever attaining the long operating lives sought for ion engines. The design goal for the EOS/NASA engine is 750 hours of continuous operation.

● **Response time**—EOS considers the response time of its propellant feed system very good. An alteration in the power transmitted to the vaporizer coil produces a change in the cesium flow rate within one second. The vaporizer is controlled by a feedback circuit that senses electron current at the ion emitter. If a reduction is sensed, current to the vaporizer coil is increased to step up the flow of cesium.

Temperatures in the storage and feed system are moderate. They should be as near as possible to the freezing point of cesium to minimize corrosion, which increases with temperature. The temperatures in the tank and wick must always be less than that in the vaporizer, where heat is used to control cesium flow rate.

The pressure in the tank is of no importance in powering or controlling the flow of propellant. The pressure in the feed tube to the ion emitter is controlled by the temperature of the vaporizer, and is normally 10 mm Hg for





photos); wetting liquid has reached its equilibrium position distributed evenly along narrow edge of segment, where it will remain for duration of weightlessness condition. Initial tests indicate pumping concept is feasible.

the contact ionization system and 0.1 mm for the gas-discharge type.

Since less capillary force is needed in the latter to overcome pressure in the tube and prevent flow reversal, it can have a more porous wick. The nominal temperature in its vaporizer is 200°C, compared with 350°C in the contact ionization type.

Spacing of the radial divider vanes in the tank can be selected to match the surface tension pumping force to the anticipated acceleration levels. The spacing for present EOS ion engines is adequate for 0.01g accelerations, although the flight test engine will provide an acceleration of only 0.0001g. The margin is to allow for unforeseen acceleration events such as micrometeorite impacts.

Porosity of the wick is also selected on the basis of the acceleration to be encountered. Low-g flight systems use a coarser wick than Earth-based lab test systems.

● **Extrapolating**—EOS has made and tested about a dozen surface tension feed systems for ion engines as well as transparent models of the "orange segment" volume between dividers. The largest tested with an engine to date contained 20 lbs. of cesium.

There is no fundamental reason why the surface tension pumping principle should not work regardless of the size of the tank or the proportion of its volume containing liquid. A blob of wetting liquid in contact with only one divider should tend to spread thinly along the wall until it contacts the opposite divider at the narrow inner end of the compartment. Then the remainder of the liquid would migrate toward the center-line in the usual fashion.

In a very large spherical tank, the ratio of contact surface to volume would be less. If this ratio should become smaller than the equivalent ratio in the feed tube, surface tension would transfer a slug of liquid into the tube, blocking the operation of the vaporizer and the ion emitter.

Feed tube geometry can be altered to prevent this, or in systems of extreme size, the tank might be made cylindrical rather than spherical to enlarge the internal surface area with respect to the propellant volume.

The zero-g system for cesium was described last week to the Fourth Electric Propulsion Conference at a confidential session. The presentation also covered the results of three programs—limitations on the lifetime of a porous tungsten button engine, development and testing of a small sastrugi engine and the development and testing of a high-thrust sastrugi engine. Extended testing with an automatic control system was also included. ■

AF Pilots 'Far Exceed' Expected Performance In Military Experiment

Two-week simulation study will influence Air Force attitude on operational missions, space-station design

by Heather M. David

VALLEY FORGE, PA.—Startling indications of man's ability to perform military space missions are coming out of a two-week simulation here in which two Air Force Aerospace Research Pilot School pilots participated.

Ramifications of the test conducted at General Electric Valley Forge space station simulation facility are expected to shape Air Force thinking about operational missions, space station design and training at the Edwards AFB Aerospace Pilot School.

Maj. Jay Currie, school faculty member who assisted in the experiment, says two crack pilots performed the operational mission profile "far exceeding the limits" expected. Their performance in mission tasks, spacecraft control and psychomotor tests were far superior to even that expected by school officials.

The two subjects were Capt. Albert R. Crews, who was one of the seven *Dyna-Soar* pilots and is now chief of the school's *Manned Orbiting Laboratory* (*MOL*) branch, and Capt. Richard E. Lawyer, a former football player for the University of California who graduated first in the space school class this year. Both are faculty members at the Aerospace Research Pilot School.

● **Performance**—These outstanding results were apparent as they emerged from the chamber Sept. 1:

—In a navigation experiment in which the *Orbiting Astronomical Observatory* (*OAO*) stabilization and control system was used to fix the spacecraft on certain stars, the pilots manually operated the system as well and better than the automatic *OAO* system. *OAO* project engineers at GE said fuel conservation was "significantly better."

—In controlling the spacecraft through complicated maneuvers, the men's performance was so good that it was determined that the type of equipment—such as the stick—is not up to the rate the pilots could perform by 50 to 100%. Currie said this would result in redesign of some equipment for the school.

—The men suffered hardly any psychological or physiological effects of the two-week confinement or heavy mission schedule. Only physiological effect was a slight weight loss. The improvement over previous performances by non-professionals is apparently explained by higher skill and motivation.

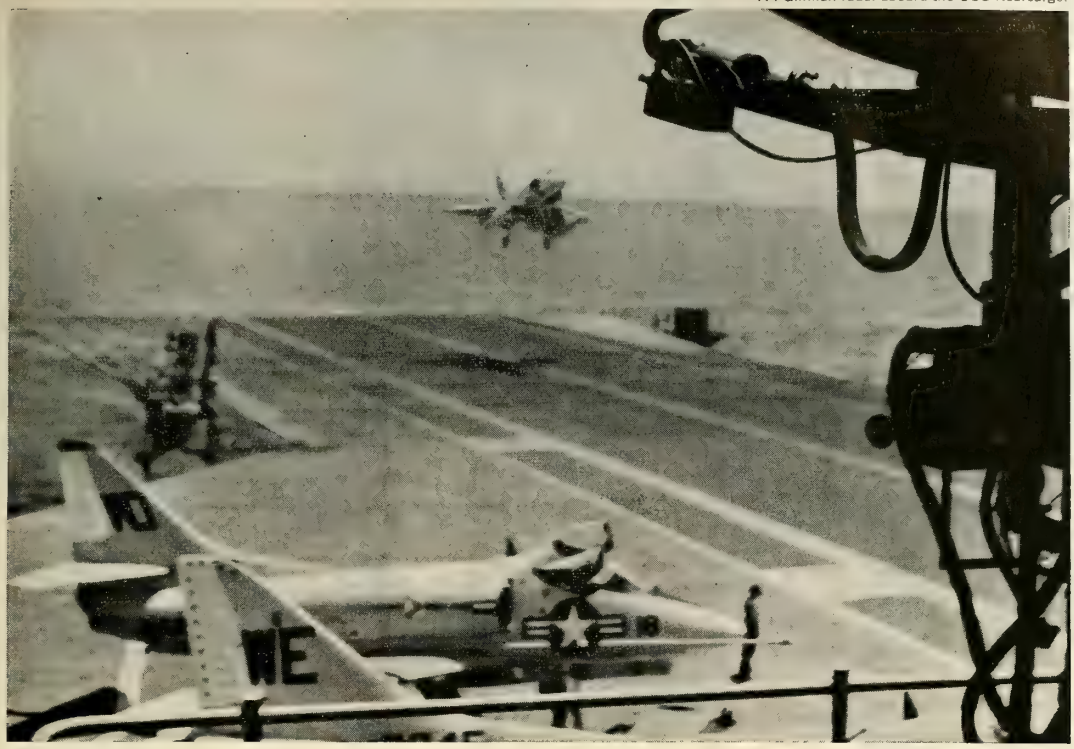
—The men's ability to regulate their time and perform conflicting tasks during real and "programmed" emergencies is setting new ideas about military missions. Many in the steady stream of observers—top brass included—agree that a new kind of thinking is necessary—that it is time to stop being conservative and send up men with a minimum of equipment and a maximum workload.

● **GE equipment**—The test was conducted at GE's manned space station simulator (M/R, Nov. 18, p. 31), which was modified to resemble the more Spartan environment which could be expected in a military mission. Only one chamber was used, 12¼ ft. in dia. x 7½ ft. high with bunks put in the attic-like torpedo tubes. These were soundproofed.

Environment was controlled from the exterior of the vacuum chamber in which the cabin was placed. Oxygen and nitrogen were used, 50/50 at 7 psi. Carbon dioxide was removed by a Hamilton Standard molecular sieve. The men operated in shirt-sleeves, except for a four-hour period in which space suits were used to evaluate their performance.

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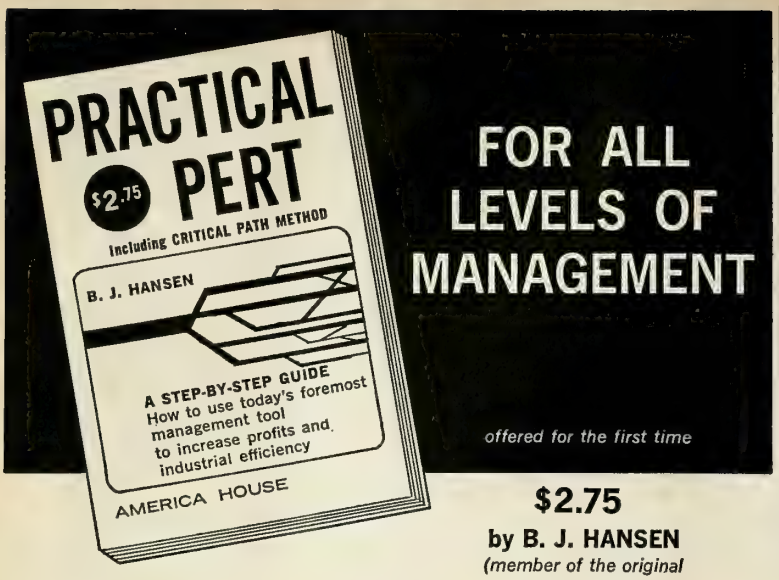
The U.S. Army, the Navy, the Marines and the Air Force, as well as a dozen foreign nations, have bought and are still buying its radar systems.

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by B. J. HANSEN

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ment was tied up in the complex simulation, including facilities in separate buildings at Valley Forge, and the computer network that coordinated them.

This equipment included with the *OAO* system a rendezvous simulator in which a TV camera picked up spacecraft models mounted on tracks. By moving the model and the carriage, rendezvous and docking could be simulated in a realistic fashion.

One interesting experience for the pilots occurred when a model on close examination turned out to have "CCCP" on the side. GE engineers also whittled out a flying saucer complete with flashing lights, and *Mercury, Gemini* and *Agena* spacecraft.

Three classified military mission tasks were performed. Without disclosing anything about their nature, the observers said that the men's performance for the first time will give the Air Force something concrete in justifying the need for man in space.

● **Sleep, work cycle**—A four-hour sleep, eight-hour work schedule was maintained by the men, who were given leave to improvise their schedule in any way necessary to maintain their mission. Unlike GE's "terrenauts" (M/R, Nov. 18, p. 31), the men were so engrossed in their mission that no time was used for recreation.

Orbit was postulated as equatorial at 90-270 miles, at 38 degrees inclination. Close adherence to a supposed nine-station communications network was kept, with the men unable to communicate for any reason when out of range.

Medical monitoring was kept to a minimum and was mission-directed, according to GE medical monitor Dr. Stan Gottlieb. Oral temperature, blood pressure, electrocardiogram, pulmonary function and respiratory rate were taken by the men during a one-hour-a-day biomed period. Exercise on a zero-g exercise machine designed by Dr. Richard Lawton and Ted Martin of GE (which closely resembled a pogo-stick), was conducted during this time.

Evaluation tests were also conducted to see if confinement, fatigue or the gaseous environment affected vision. However, no major results emerged.

Following the Spartan idea, food provided gave the men only one solid-freeze-dried meal a day. The other two were liquid. All were provided by Libby McNeill & Libby. Hygiene involved only a sponge bath each day.

Air Force participation in the test was directed by Maj. John Prodan, chief of simulation at the school. The program was directed at GE by Richard Passman, manned space operations chief at the Missiles and Space vehicles Department, and Carl Cording, project engineer. ■

contracts

AIR FORCE

$62,396,400—**Thiokol Chemical Corp.,** Brigham City, Utah, to make stage one motors for the *Minuteman* ICBM.

$10,000,000—**North American Aviation, Inc.,** Anaheim, Calif., for continued work on the *Minuteman* guidance and control system.

$6,400,000—**American Air Filter Co., Inc.,** Louisville, Ky., for environmental control support equipment for Wing VI *Minuteman* missiles.

$5,000,000—**Avco Corp.,** Stratford, Conn., part of a $26-million contract to make re-entry vehicles.

$3,828,469—**Reynolds Metals Co.,** Richmond, Va., for electronic countermeasures material.

$1,238,000—**TRW/Space Technology Labs,** Redondo Beach, Calif., for engineering support for the *Minuteman* program.

$800,000—**McDonnell Aircraft Corp.,** St. Louis, for the *ASSET* program.

$428,000—**Cook Electric Co.,** Tech-Center Div., Morton Grove, Ill., for a control center programmable patching audio communications system from the Eastern Test Range at Cape Kennedy, Fla.

$325,000—**Collins Radio Co.,** Dallas, for technical assistance in a program for investigating airborne transmission of microwave frequencies.

$263,000—**Douglas Aircraft Co.,** Missile & Space Systems Div., Santa Monica, Calif., for repair, calibration, re-certification services of precision measurement equipment in support of *Agena* program.

$214,200—**Trustees of Princeton Univ.,** Princeton, N.J., for research on hypersonic flows.

$150,000—**Gianinni Controls Corp.,** Astromechanics Research Div., Malvern, Pa., for model simulation of full-scale flight vehicles.

$129,155—**Martin Marietta Corp.,** Denver Div., Denver, Colo., for engineering services necessary to perform system integration and in-service engineering support to *Titan* weapon systems.

$117,000—**General Telephone & Electronics Corp.,** Sylvania Electric Products, Inc., New York City, for the production of semiconductor devices to meet military specifications.

ARMY

$14,375,776—**Hughes Aircraft Co.,** Culver City, Calif., for continued research and development of the *TOW* missile system.

$8,129,344—**Olin Mathieson Chemical Corp.,** Charlestown, Ind., to make propellant charges.

$3,835,000—**Radiation, Inc.,** Melbourne, Fla., to modify communications satellite ground terminals.

$2,999,796—**General Precision, Inc.,** Clifton, N.J., for the manufacture of hydraulic actuation systems for the *Pershing* missile system.

$2,718,960—**McDonnell Aircraft Corp.,** St. Louis, for an exploratory development program for missile antitank weapons.

$2,533,766—**Western Electric Co.,** Burlington, N.C., to modify *Nike-Hercules* missiles.

$2,360,000—**Collins Radio Co.,** Dallas, to provide an intercom system for NASA's operations and checkout building at Merritt Island, Fla.

$1,088,787—**AT&T Co.,** Western Electric Co., Inc., for engineering services for, and modification and maintenance of equipment in support of the Sleigh Ride re-entry test program.

$650,000—**Western Electric Co.,** New York City, for engineering design, modification and servicing of missile ground guidance equipment.

$340,124—**Sperry Rand Corp.,** Salt Lake City, for concurrent repair parts for *Sergeant* missile system.

NAVY

$1,441,994—**RCA,** Morristown, N.J., for the continued production of indicator groups for ASW equipment.

$1,121,848—**American Machine & Foundry Co.,** Advanced Products Group, York, Pa., to manufacture Mark 37 Model O motor inert parts for *Asroc.*

$172,500—**Lieco Inc.,** Syosset, N.Y., for 15 radar training devices.

NASA

$1,939,000—**Greenhut Construction Co.,** Marshall Space Flight Center, for building an extension to a rocket components testing building.

$228,000—**General Dynamics/Convair,** San Diego, Calif., for research in a mathematical approach for advance prediction of vibration effects caused by aerodynamic flow on skin panels of aerospace vehicles.

$220,690—**Lockheed Aircraft Corp.,** Lockheed Missiles & Space Co., Sunnyvale, Calif., for a design study for an orbital tanker.

$159,286—**Excelco Developments, Inc.,** Silver Creek, N.Y., to continue study and evaluation of fabrication methods necessary for production of large-diameter solid propellant rockets.

$149,359—**Goodyear Aerospace Corp.,** Space & Technology Div., Akron, Ohio, for study and conceptual design of expandable modules for lunar surface operation.

Kaman Aircraft Corp., Bloomfield, Conn., to design and fabricate a rotary wing recovery system wind tunnel model for the investigation of re-entry deceleration and recovery of manned space vehicles and aerospace payloads (amount undisclosed).

INDUSTRY

$2,000,000—**Energy Systems Inc.,** Palo Alto, Calif., from **Collins Radio Co.,** Dallas, to build 20 high-power microwave transmitters for the new NASA Unified S-Band Network.

$500,000—**Leach Corp.,** San Marino, Calif., from **North American Aviation, Inc.,** Space & Information Systems Div., Downey, Calif., for instrumentation data acquisition and storage units.

$200,000—**Haveg Reinhold Inc.,** Santa Fe Springs, Calif., from **Aerojet-General Corp.,** Sacramento, Calif., for the fabrication of tape-wrapped nozzle extensions for the second stage of the *Minuteman II* ICBM.

$57,105—**Aerospace Research, Inc.,** Boston, from the **Massachusetts Institute of Technology,** Lincoln Laboratory, Cambridge, Mass., for the design and development of special-purpose delay line driver amplifiers and post delay amplifiers.

Melpar, Inc., Microwave Physics Corp., Garland, Tex., from **RCA Victor Co., Ltd.,** Montreal, Quebec, for a paramp system contract for Canada's Dept. of Transport's new Earth Station to be installed in Nova Scotia for satellite communications use (amount undisclosed).

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No Further SERT-type Tests Needed

Lewis Center expert reports that success of first flight satisfies data needs; $3-billion electrical system seen

PHILADELPHIA—There will be no need for future ion engine space tests along the lines of the recent NASA *SERT* tests due to the phenomenal success of the experiment.

Howard Childs, chief of the Spacecraft Technology Div. at NASA's Lewis Research Center, presented the details in a surprise paper at the Fourth Electric Propulsion Conference here on Aug. 31.

Childs told the conference that three separate thrust checks were run on the ion engine during the flight and all checked with each other and with previous data obtained in vacuum chamber runs. The thrust-vs.-time data also agreed with calculated results based on ground tests—after the necessary corrections were made.

In addition, a small probe placed in the ion exhaust stream about 7 in. behind the thrustor showed a beam spread similar to that experienced in ground tests. Command transmissions were made before and during ion engine operation without any appreciable effect on signal quality. This was double-checked by clean telemetry information.

Childs said there is no doubt that no beam neutralization problem exists in ion engines as currently designed. He also told the meeting that more perfect data could not possibly be obtained from a flight test.

In general, performance data looked exactly like that derived from the numerous ground tests run in vacuum chambers with the NASA engine.

If there are any future ion engine tests, Childs told MISSILES AND ROCKETS, the test objectives would be essentially different from those in the *SERT* flight.

● **$3 billion plus**—An electrical propulsion system in the megawatt power area based on the Rankine cycle approach could easily cost more than $3 billion over a 12-year development and test-time period.

Benjamin Pinkel, associate head of the Aero-Astronautics Dept., The RAND Corp. detailed this and other pertinent aspects drawn from a study funded by NASA on the planning and funding relative to such electrical propulsion systems. He spoke before a classified session at the Third Biennial Aerospace Power Systems Conference, also held here.

Pinkel summarized vehicle weights and costs for advanced space missions using electrical propulsion systems. He also covered competing chemical and nuclear systems; this included manned Mars expeditions, lunar logistic transport and deep space-probe missions.

Mission studies, according to Pinkel, revealed no economic or performance advantage sufficiently compelling to warrant the early initiation of a full-scale development program based on proposed Rankine cycle technology.

The RAND expert recommended that present emphasis be placed on exploratory engineering studies relating to Rankine, Brayton and thermionic systems, coupled with research on new technologies in the area.

Although the actual paper was given in a classified session, the published abstract hinted at the complex economic and technical problems associated with development of space power-generation approaches.

● **Electrical thrustor progress**—The Power Systems meeting succeeded the Fourth Electric Propulsion Conference at the Bellevue Stratford Hotel. The two meetings, each an integral part of the other, were annual conferences of the American Institute of Aeronautics and Astronautics (AIAA).

Electrical engines have long since passed the point of successful ground operation in altitude simulation chambers and are progressing into problem areas far in advance of their necessary power supply. The recent suborbital flight of a pair of thrustors exceeded all expectations despite the failure of one device to operate.

The major drawback to electrical propulsion devices has always been lack of a reliable, long-duration power supply. The Electrical Propulsion Conference covered a host of highly detailed aspects of the various devices. Most of these were progress reports on particular aspects of the engines.

A key paper covered the total analysis of such systems and their allied power complexes.

When power conversion, power conditioning and thrusters are included in electric spacecraft mission analysis, the total effective specific mass of the electrical propulsion system may be much higher than that of the electrical power plant alone.

The electric powerplant is often assumed to be by far the heaviest component of such systems, but a method of system analysis presented by William R. Mickelsen of Lewis Research Center shows that the propulsion section has a significant effect on payload loss or increased trip time.

Mickelsen's results indicate that existing electric thrustors are primarily responsible for the large specific masses because of an inability to operate with a variable specific impulse, requirements for power conditioning, thrustor mass and thrustor inefficiency.

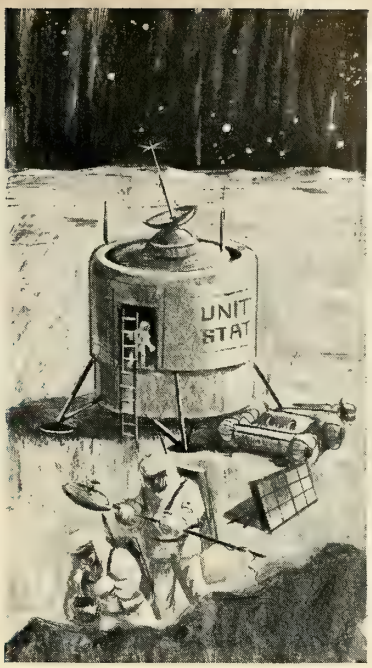
The Lewis scientist called for increased attention to advanced electric powerplants and thrustor concepts. For example, he says powerplants with outputs matched directly to the thrustor would eliminate power-conditioning losses. Lightweight thrustor systems with efficiencies over 90% and with multi-step specific impulse operation are also needed.

Mickelsen says his analysis shows that conventional power-conversion and power-conditioning systems coupled with existing electric thrustors would produce unacceptably great increases in the effective mass of electric propulsion systems intended for primary propulsion on interplanetary space missions.

A combination of state-of-the-art power-conversion and power-conditioning systems with existing electric thrustors would result in a propulsion system specific mass two or three times as great as the specific mass of the powerplant alone.

Mickelsen says power conversion and conditioning systems should be much more efficient and lightweight or replaced entirely by advanced concepts. If these cannot be realized, then direct coupling is desirable. ■

beyond apollo—
the U.S. space program



4th annual NASA issue

november 30, 1964

MISSILES AND ROCKETS, the weekly of Space Systems Engineering, will publish its fourth annual NASA Issue on November 30, 1964.

This annual issue, now accepted as the authoritative publication on the nation's space agency, will examine future procurement plans of the National Aeronautics and Space Administration and three organizations allied with it in exploring the peaceful uses of space, Communication Satellite Corporation, Atomic Energy Commission and the U.S. Weather Bureau.

With major procurement for the Apollo manned lunar landing program now behind it, NASA is deep in the planning for new projects to expand man's knowledge of space, including such post-Apollo missions as the Lunar Logistic Supply System, Manned Orbital Research Laboratory, Extended Apollo, Project Voyager and Manned and Unmanned Planetary Probes. ComSat Corp., AEC and the Weather Bureau are drawing up plans for their growing participation in the peaceful use of space.

This issue of MISSILES AND ROCKETS provides the recognized and authoritative route to reach the men who will be making the research, design, engineering and procurement decisions in these new multi-billion dollar programs.

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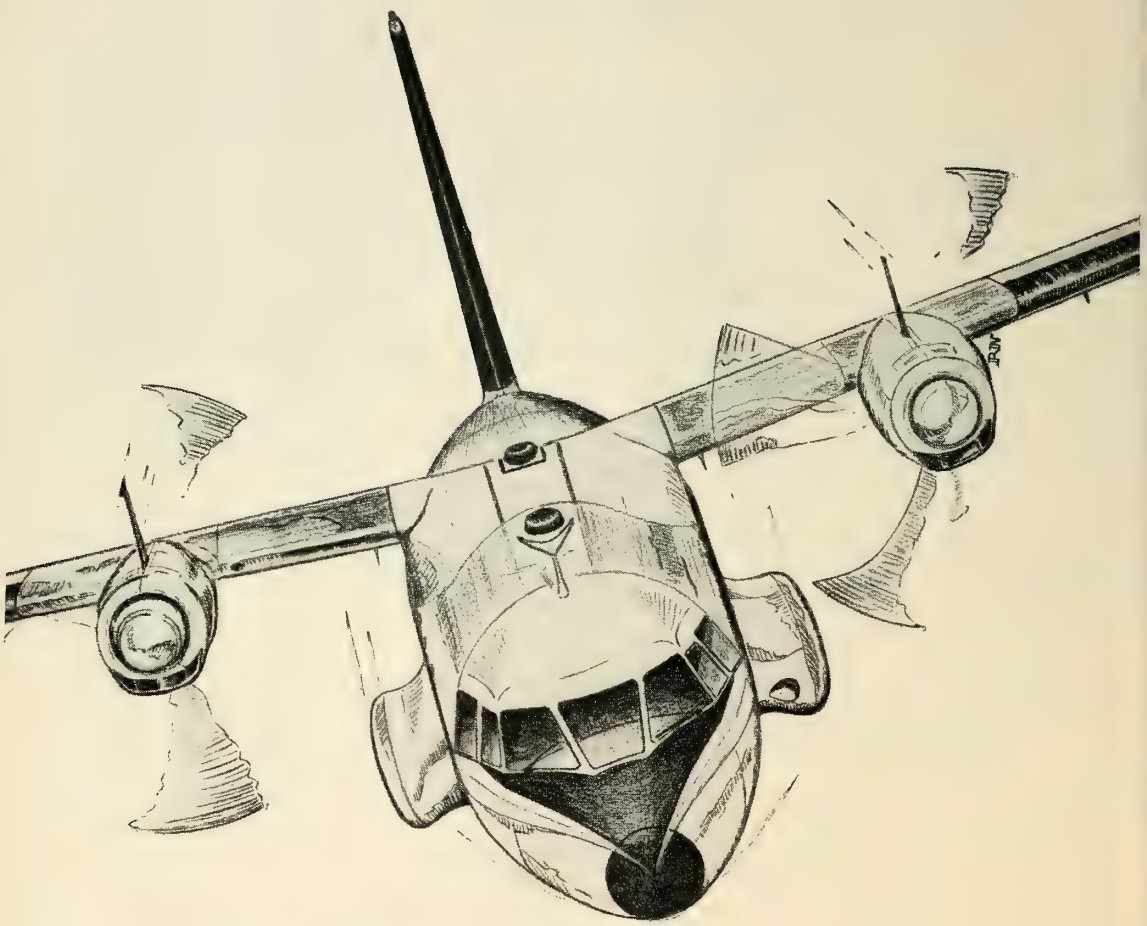
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Mergers and Acquisitions

International Telephone and Telegraph Corp. has entered a preliminary agreement to acquire the business and assets of Barton Instrument Corp. of Monterey Park, Calif., for $11 million in ITT common stock. Exchange rate will be 0.2922 share of ITT for each share of Barton. Barton makes flow and level measuring instruments. . . . *Raytheon Co. has purchased the computer division of Packard Bell Electronics Corp. for an undisclosed amount of cash. Raytheon plans to strengthen the division's product engineering to expand its capabilities in military electronics systems and scientific and commercial electronics.* . . . The Curtiss-Wright Corp. is bidding for control of Lynch Corp., a firm engaged in manufacturing phonograph equipment and packaging equipment. Lynch stockholders will vote on the proposition Sept. 18. . . . *Avco Corp., New York City, is seeking to absorb Delta Acceptance Corp., Ltd., a London, Ontario, firm engaged in the dealer and consumer loan business.* . . . Genisco Technology Corp., Compton, Calif., has acquired Products of Technical Dynamics in Santa Barbara as part of its recent purchase of Jamieson Industries, Inc., (M/R, Aug. 3, p. 35). Technical Dynamics will be operated as a division of Genisco and will be used to establish that firm in the field of underwater technology. About 80% of Technical Dynamics' sales volume has been composed of active and passive sonar components, sonar transducers or hydrophones and other fully assembled underwater acoustical devices for propagation and receiving of sound signals.

Radiation Inc. Gets Credit Fund

Radiation Incorporated of Melbourne, Fla., has obtained a $10-million revolving credit fund over a three-year period to help finance continued growth. Banks involved in the credit agreement are First National, Orlando, Fla.; Wells Fargo, San Francisco; Atlantic National, Jacksonville, Fla.; and the Philadelphia National. The firm produces telecommunications, data handling and control systems for industral and aerospace use.

Missile/Space Facilities

Space-General Corp., a subsidiary of Aerojet-General Corp., plans to add to its El Monte, Calif., facilities a two-story building to house engineering, office and manufacturing activities. Completion of the 66,000-sq.-ft. building is expected in March, 1965. Design and construction is being handled by Aetron, a division of Aerojet-General. . . . *Dynaelectron Corp. and its subsidiary, Air Carrier Service Corp., have relocated their headquarters in a newly constructed building in Washington, D.C. Dynaelectron, which moved from Chicago to Washingtin in 1959, is active in missile and aircraft maintenance, missile range operation and data reduction.* . . . Union Carbide Corp. has opened a new facility in Mountain View, Calif., to manufacture semiconductors and integrated circuits and has begun producing n- and p-channel field-effect transistors. . . . *Edler Industries, South Gate, Calif., a missile component fabricator, expects to occupy a new 75,000-sq.-ft. plant in Newport Beach, Calif., in late October. The facility has been engineered and designed as a special-purpose plant for metal and phenolic fabrication.* . . . Houston Instrument Corp., Houston, has moved its Auto Data Div. to San Diego, Calif. Transferred to the California operation will be all marketing, manufacturing and engineering activities of Houston Instrument's digital voltmeter line.

International

Hughes Aircraft Co. and Nippon Electric Co. of Tokyo have agreed to conduct joint research and development work on communications satellite equipment. Hughes will work on satellite hardware while Nippon Electric will study ground communications facilities. . . . *The Norden Div. of United Aircraft Corp., Norwalk, Conn., and Vactric Control Equipment, Ltd., Surrey, England, have exchanged letters of intent through which Vactric will acquire exclusive sales rights for Norden's line of analog-to-digital converters in the United Kingdom, and non-excusive rights to the line in the rest of the world, with the exception of France, Canada and the United States.*

New Activities

Products for Research has been formed in West Acton, Mass., to provide thermoelectric and refrigeration devices for research and industry and has purchased the right to the temperature controlled refrigerated chamber for photomultiplier tube operation from Technical Operations Research of Burlington, Mass. . . . *Industrial Science & Arts, Inc., has been formed in Cambridge, Mass., to perform chemical milling, photoetching and related processes for industry.*

Tektronix Gets WEMA Medal

Tektronix, Inc., Beaverton, Ore., has received the 1964 Western Electronics Manufacturers Assn. Medal of Achievement for "notable achievements in electronics, and distinguished service to country and community." Tekronix president Howard Vollum, the developer of the cathode-ray oscilloscope, accepted the award for the firm.

Company Representatives

International Rectifier Corp., El Segundo, Calif., has appointed Gulf Semiconductor its industrial distributor for the Coral Gables, Fla., area. International makes low, medium and high power diodes and rectifiers, zener diodes, controlled rectifiers, solar cells, and both silicon and selenium photocells. . . . *Aerospace Avionics, Inc., Farmingdale, N.Y., has named Orbit Electronic Sales Co. its exclusive sales representative for its line of test equipment, instruments and ground support equipment systems in Missouri, southern Illinois, Kansas and Oklahoma.*

First of Some 50 Block II Apollo G&N Computers Is Due by Mid-1965

Dividend from development is elimination of some shortcomings of Block I G&C; interface principles increase system reliability

by Rex Pay

LOS ANGELES—Twenty-five Block II *Apollo* guidance and navigation computers are scheduled for use in Command Modules, and a similar number are slated for the Lunar Excursion Module. First Block II machines will be delivered in mid-1965 (M/R, March 16, p. 28).

In the meantime, technological advances enabling the use of the more capable Block II machine have removed some of the limitations foreseen earlier for the Block I *Apollo* guidance and control system. Previously the stabilization system was in series with the guidance and navigation system. Malfunction of the control system would therefore render the G&N system helpless.

In the Block II arrangement, the G&N system and the control system represent parallel paths to the attitude jets and engine gimbal drivers. The G&N (or more properly GN&C) system now serves as the primary system. The control system serves as a backup.

These changes were described by Dr. Robert C. Duncan, Chief, Guidance and Control Division, NASA Manned Spacecraft Center, at a session on *Apollo* electronics during the recent WESCON meeting.

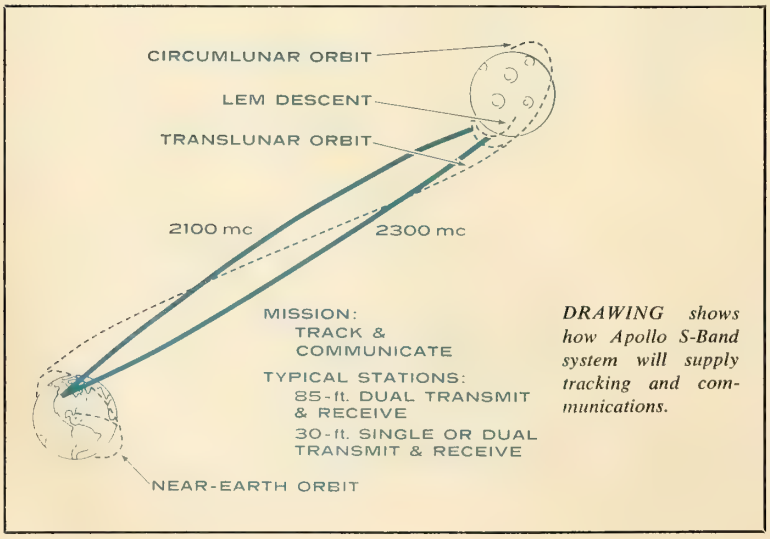
He pointed out that one advantage of the new arrangement was that the redundant systems are separate.

● **Notable computer**—Control functions in the G&N system are obtained by a direct interface between the computer and the control-jet solenoid drivers. The computer, through programming, can now provide optimum control of the jets. This was previously carried out solely by control system electronics. In addition, the computer now derives rates, properly sums the rates with attitude error, and transmits steering signals directly to the engine gimbal drives.

"In general," said Duncan, "the Block II *Apollo* Guidance Computer is a very powerful, lightweight, small computer with the largest memory of any airborne computer in history."

Block II AGC is a binary, 15-bit single-address, parallel "general-purpose" computer. The logic element is a three-input, modified DCTL, NOR gate. A change has been made from the silicon-diffused integrated circuit to an epitaxial grown circuit.

TO-47 cans are no longer used, and two NOR gates sharing power and



DRAWING shows how Apollo S-Band system will supply tracking and communications.

ground leads will be encapsulated in one flat package. Use of the flat packs saves 20 lbs. in weight and improves reliability. Lead breakage and pack leakage problems associated with these packs will be avoided by instituting special handling and screening techniques.

Because of the use of epitaxial circuits, the power requirement will be reduced from 90 to 75 watts. This also alleviates thermal problems caused by greater component density in the new modules. Packaging consists of welded, potted modules and wire-wrap interconnection.

Three types of memory are present. Largest part is 24,000 words of fixed-wire, core-rope memory. Second type is 2,048 words of erasable, coincident-current ferrite cores. Some 20 solid-state arithmetic, control, and input-output registers represent the third type.

● **More reliability**—Application of certain interface principles has improved reliability, said Duncan. These principles include electrical isolation from other subsystems, asynchronism, compatability, absence of analog transmissions in magnitude form, and output feedback.

Ability to accept inputs asynchronously to the computer timing systems has made possible design with minimum reference to external circuits.

Compatibility enables the computer to check its own interface by having outputs drive the inputs. Output feedback affords a means of fault detection and correction.

The functional capabilities are expanded in the new computer. The instruction set has been expanded from 11 to 31, including some double-precision operations. In addition, the multiply instruction execution time has been reduced from eight to three memory cycle times and the division time from 16 to six. These modifications plus several other useful instructions have served to double the computer speed.

To accommodate the expanded discrete output requirements of the Block II system, additional output registers and a new scheme of indirect addressing are added. The Block II counters controlling commands to various appliances have been increased in number and rearranged in order to provide a substantial increase in input-output capability by allowing simultaneous control of all coupling data units. One of the additional output counters is designed to allow communication between the Command Module and Lunar Excursion Module computers.

The Block II computer envelope has been modified to improve thermal control and to give better moisture sealing of the connectors.

● **Spacecraft sealing**—Problems of moisture sealing in the *Apollo* spacecraft were highlighted at the same session by Dr. Joseph F. Shea, Manager, *Apollo* Spacecraft Program Office, NASA-MSC.

Although the specified atmosphere (70-80°F and 40-70% R.H.) sounds benign, isolated spots on the cabin wall can be below the dew point. Also, spillage of fluids by the crew is considered quite likely.

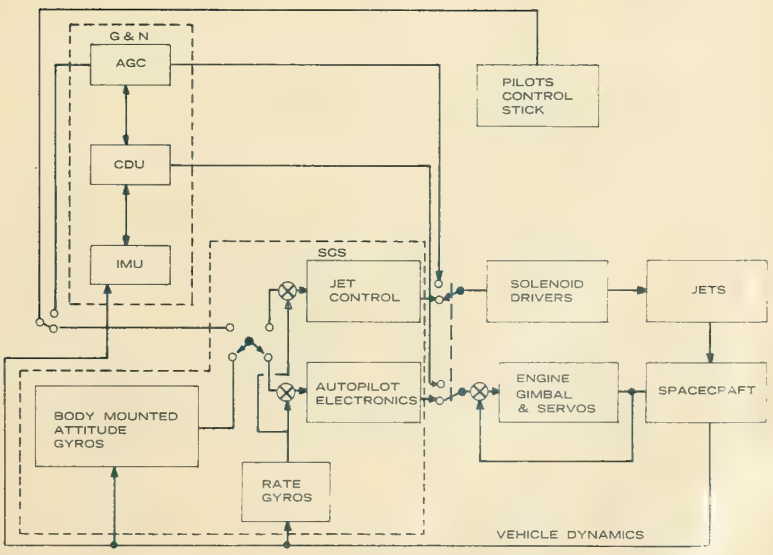
Gordon Cooper's 34-hour flight showed that such fluids, in zero-g, are attracted by potential fields around electronic systems. Once deposited on a surface, the fluids seem to penetrate minute openings more easily than in ground tests, because surface tension and capillary forces no longer have to compete with gravity. The pure oxygen environment also speeds corrosion.

Command Module qualification test for moisture now calls for 50 hours operation in a 1% salt fog and 240 hours at 95% relative humidity oxygen cycled between 3 and 7 psi.

Speaking of reliability in the *Apollo* electronics, Shea said "perhaps the most significant philosophical aspect of our approach is that we do not believe in random failures. In the limit, every failure has an identifiable cause which can be corrected."

He said that by focusing on the individual flight article, NASA expected systems to show a "probability of success" significantly greater than that predicted by conventional reliability statistics.

Shea said that in-flight maintenance ideas had been abandoned, because "systems designed for in-flight maintenance will justify that decision by inherently requiring more maintenance." Present approach is to use redundancy to compensate for failure. ■



APOLLO BLOCK II guidance, navigation and control system has increased reliability through use of redundant paths, made possible by improved computer.

Millimeter Systems Seek a Program

Interest in new components grows with available power; early application may be found in reconnaissance radar

LOS ANGELES—The continuing rapid advance in development of millimeter-wavelength power-generation devices—a major obstacle to application of millimeter electronics in a number of proposed space and defense roles—is now spurring new attention to the second-step technical developments required for working systems.

It is also leading to an intensive sifting process to sort the realistic applications for these systems from all those which have been proposed.

A relatively small group of electronics firms has pushed this technology hard for several years, but during the past year progress has accelerated and the circle of supporters has noticeably enlarged (M/R, Nov. 11, p. 35).

Growing interest in millimeters was much in evidence at the recently concluded WESCON meeting here (M/R, Aug. 31, p. 14), where lasers were "outauthored" by millimeter presentations six to four.

If hardware can be matched to the inherent capabilities of millimeter operation, the range of application is very large.

Millimeter systems operate at the very-short-wavelength end of the electromagnetic spectrum, generally classed between 30 and 300 gc or, expressed in millimeters, roughly between 10 and 1 mm. It is the very-short-wavelength characteristics which have made this technology so appealing to a number of firms and government agencies, although the technology itself has been virtually overwhelmed in terms of funding and publicity by the potential of the neighboring optical frequencies.

Proponents of Mm systems argue that development basically involves an extension of conventional microwave technology to open up a new area of the spectrum, rather than creation of a whole new technology in the optical portion.

Lasers, and lack of good Mm sources, have not been the only problems, however. In fact, the awareness that lasers may have some insurmountable problems for certain proposed radar and communications applications is one of the reasons why millimeters are getting another hard look.

One problem, a scientist points out, is that whatever funding has been made in the Mm region has largely been aimed at state-of-the-art areas, rather than having firm systems specifications imposed on designers in order to deal with practical hardware problems.

● **Clear role needed**—Whatever the problems and potential, the introduction of Mm systems into U.S. defense and space programs on a major scale still awaits the emergence of a critical and clear-cut mission which these systems can perform and that microwave and optical systems cannot.

More than one expert believes that such a critical area will emerge, at first probably in very-high-resolution airborne (or possibly spaceborne) reconnaissance radar.

These experts say use of the shorter wavelengths would provide a number of advantages for such radars including very narrow beamwidth with associated high angular resolution and efficient high-gain utilization of even small antenna apertures; good Doppler sensitivity and range resolution; and good side lobe control. While effect of atmospheric attenuation and scattering on Mm waves is still not completely understood, the wavelengths have shown certain all-weather penetrability which would enable them to function over cloud- or fog-covered terrain where laser systems probably could not.

Widespread work is in progress on the development and use of synthetic-aperture-type reconnaissance and mapping radars, many of which are of the so-called side-looking variety, and advocates of Mm systems see the combination of the two as a strong possibility.

Very narrow beams would allow considerable data collection even with very small-aperture radar, one expert told M/R, and the use of the short wavelengths could also enable getting radar photos in time spans which would not permit use of the longer wave microwave systems. One scientist estimates that use of radars operating in the 3mm (94gc) region, where considerable development effort is directed, could yield photos with 10 times the resolution of X-band systems.

Mm systems could also ease the growing data processing requirements of reconnaissance radars, M/R was told, primarily because the inherent high resolution of Mm waves would allow use of basically unfocused radar systems, in which the data-processing requirement is reportedly simpler in comparison to the focused systems operating with longer wavelength radars.

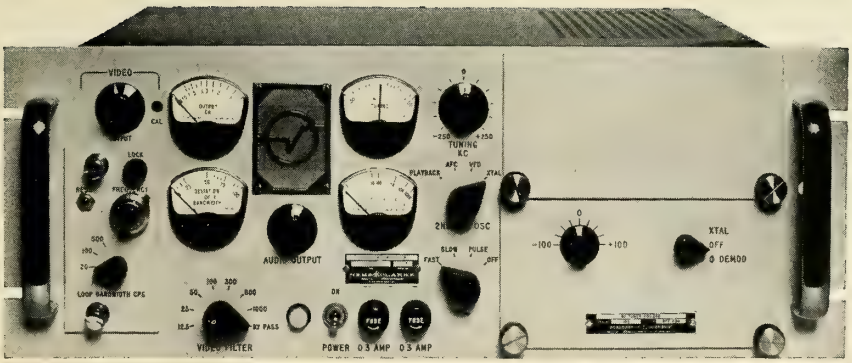
Use in flight systems will depend to a large extent on secondary power-source considerations—such as the ability to build highly stable transmitters and devices with relatively long operating lifetimes and high reliability. Some Mm tubes have already been developed which show 6,000-hr lifetimes.

Many of the advantages of the reconnaissance radar are also attached to longer-range active radars, which advocates say could be an effective spacecraft-profiling instrument.

The Mm systems role in radio astronomy as a sensitive passive device is well established and has been going on for several years. At WESCON, Frank J. Low of the National Radio Astronomy Observatory reported on the major sensitivity gains made using low-temperature germanium bolometers with a 5-ft.-dia. radio telescope using the 1.2-mm window.

Low said that the techniques can be expanded to longer (4- and 8-mm) wavelengths, with some possible decrease in sensitivity, though he said the addition of a low-noise traveling wave-tube to the bolometer would add to performance. He also noted that use of new beam-spoilers to help cancel sky background emission has worked well and appears to offer another order-of-magnitude increase in sensitivity over current levels.

NASA's Goddard Space Flight Cen-



This is the world's most advanced VHF/UHF receiver. In the recent NASA/JPL Ranger 7 moon probe it participated in such important commands as mid-course correction and antenna changeover. These receivers are in use at all deep space instrumentation facilities at Goldstone, California, Cape Kennedy, Florida, Johannesburg, South Africa, and Woomera, Australia. They are special modifications of the Nems-Clarke solid state type 1037A...by Vitro Electronics. Write for information.

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Vitro

Circle No. 12 on Subscriber Service Card

ter has been involved in a sub-millimeter radiometer project for a number of years and is now believed to be looking at a satellite-mounted device for space observation.

In the area of passive military surveillance sensors, there are at least a dozen proposed applications.

Scientists from Aerospace Corp., addressing a WESCON audience, reported on work with the 15-ft. steerable antenna which has been operating as a radiometer at 3.2 mm since December at the El Segundo site. Results to date in some instances show attenuation to be less than anticipated.

● **Communications**—Two way space-ground communications ranks as the second most likely area for Mm system deployment, according to some scientists here. However, considerable effort will be required in improvement in low-noise receivers, phase-lock loops, and transmitter stability before such systems are feasible.

While atmospheric absorption increases with frequency, there are a number of "windows" through which, many scientists believe, millimeters can propagate (at 8, 3.2, 2.2 and 1.2 mm) well enough to take advantage of the high gain and large bandwidth available. Many studies are under way in industry and government to better define these windows and the losses associated with each. Much of the future Aerospace Corp. efforts with its 15-ft. dish, built by the Rohr Corp., will be aimed at this, operating mostly in the 94 gc area.

Aerospace Corp. scientists say that "a reasonable near-future application" for a 3mm system would be a space-to-ground command link, using the 15-ft. antenna on the ground and about a 4-in.-dia. dish with an estimated 36.4-db gain aboard a satellite at synchronous altitude. A one-watt transmitter on the satellite would provide a good S/N margin, say the scientists, and provide about a 1-kc bandwidth. Beamwidth from synchronous altitude would describe about a 1,000-mile diameter on Earth.

● **ATS possibility**—An interesting sidelight to this suggestion is that just such a link with a synchronous-altitude satellite is a possibility for NASA's multiple-mission *Advanced Technology Satellite (ATS)* series. When initial planning for *ATS* was under way, it is believed that DOD suggested that a feasibility demonstration for a millimeter system, probably in the 94 gc region, be included as an experiment. No action has been taken along these lines to date, and the first of the five satellite series to be launched into a medium-altitude (6,000-mi.) orbit in late 1966 already has a full experiment load.

There is however, room for about 4-5 more experiments on the last four flights in the series, which will begin about six months after the first shot and continue on a six-month launch schedule. All of these last four flights will be lofted to synchronous altitudes, the first two being spin-stabilized and the last two employing both initial spin stabilization and then gravity-gradient techniques. The first medium-altitude shot will also use gravity-gradient.

In an attempt to provide useful experiments for the available space, NASA is expected to generate a rather general *ATS* RFP this week or next which may well turn up the type of millimeter experiment initially sought.

● **Receiver need**—Probably the most critical communications need is for better low-noise receivers. There is considerable hope for new parametric amplifiers which some scientists say should bring a 10-db noise figure with it, down from current 20-30-db levels with conventional mixers and crystal detectors.

A scientist from TRG, Inc., addressing the WESCON meeting, said his firm hoped to have a 10-db paramp operating at 94 gc available in about one year. Receiver needs are also focusing attention on making better use of commercially available diodes as well as developing special-purpose diodes. New waveguide forms are also getting increased R&D as scientists view new power-handling and breakdown problems associated with higher-power tubes.

● **Other jobs**—Another communications role which could accrue to millimeters is that of secure space-to-space radar and communications transmission. In this case, the system might operate at 5 mm, taking advantage of the atmospheric opaqueness in this region in order to insure against electronic eavesdropping from Earth on stray radiations, and also to cut clutter from Earth interference.

The short wavelengths also have an advertised capability to penetrate high ion densities or plasmas better than some other techniques and therefore are also suggested as a means to provide discrimination radar able to pierce the nuclear cloud of an ABM burst or the plasmas associated with spacecraft re-entry into the atmosphere.

In both cases, however, some scientists believe that millimeters might not prove to be the best, or simplest, way to get through or around these problems. For one, the short wavelengths are also likely to be sensitive to the turbulence that would also surround a nuclear burst. New studies and tests are expected to help define just how sensitive they are.

D. C. Forster of the Hughes Research Laboratories provided the WESCON audience with a detailed review of the currently available Mm sources. He also noted that increasing numbers of relatively inexpensive klystrons of Japanese manufacture have entered the U.S. market and that a sizeable effort in the high-power tubes was going on outside the U.S., particularly in France.

Forster reported that available power levels between 30 and 100 gc have increased by three orders of magnitude since 1960, and that source efficiencies are now competitive with microwave devices. While the technology to 100 gc is now fairly well in hand, Forster urged more new effort at higher frequencies to open up systems possibilities through perhaps 300 gc.

One-kilowatt cw sources are now available at 35 and 55 gc, he reported, with efficiencies up to 35%. These levels, being achieved using "reasonable voltages," have operating lifetimes of several thousand hours. Forster also cited gains in economical manufacture and new techniques for making lightweight sources for aerospace use.

Forster divides his survey into cw and pulse sources and further divides the cw into low and high categories, making the division at 1 watt cw. Some of his source assessments follow:

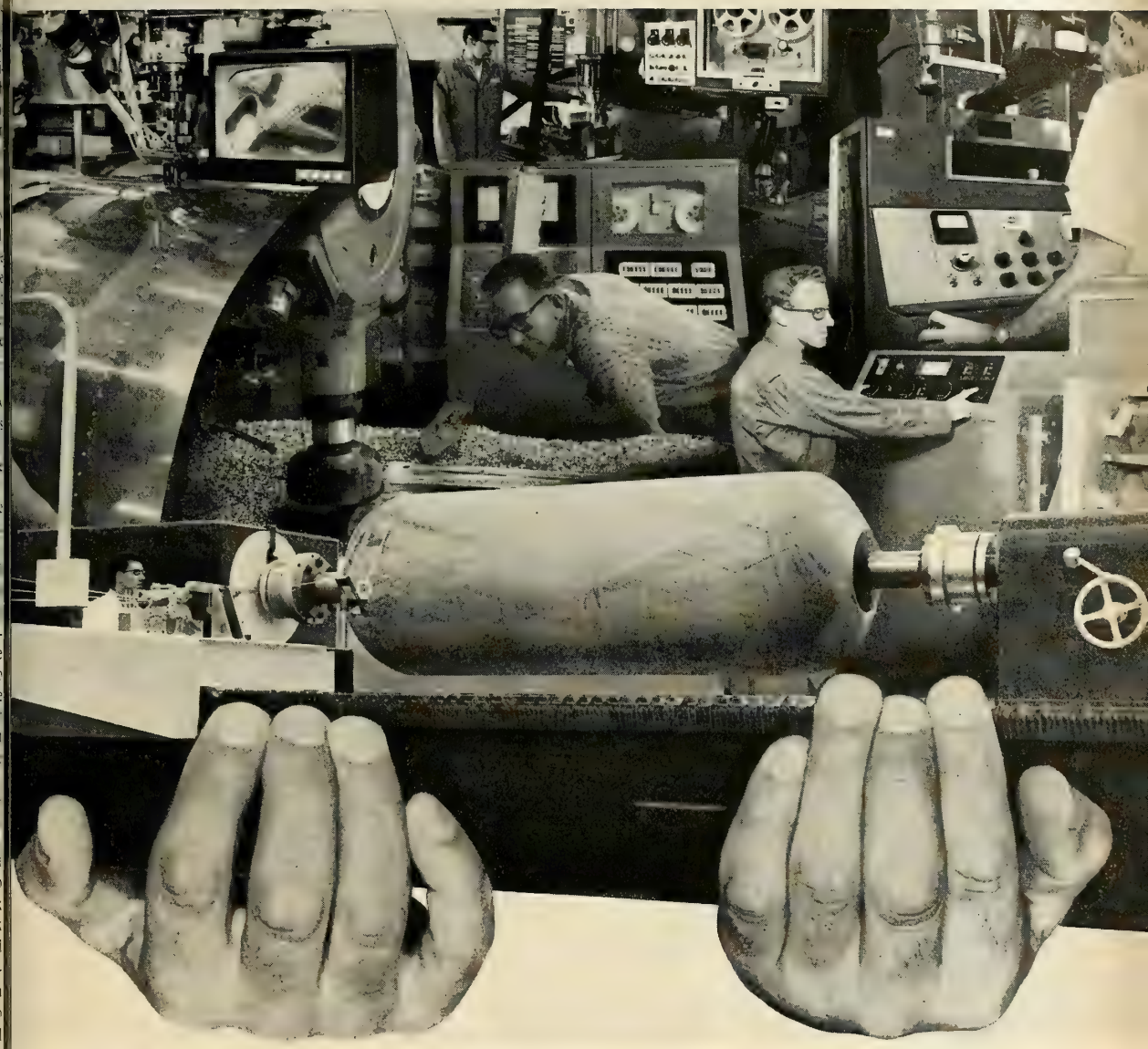
—All of the commercially available low-power cw sources are either backward-wave oscillators (BWO) or klystrons. Four companies market BWO lines, the most complete being the TWO series of Bendix which ranges from 40 to 140 gc. Sperry has developed a similar line to about 90 gc. Siemens-Halske markets a series of devices from 26.5 to 90 gc. CSF of France dominates the very high frequency range above about 140 gc with a series of milliwatt output devices approaching 500 gc and one oscillator which operates at 708 gc.

—Many firms market extensive reflex klystron lines operating to 170 gc. Most extensive coverage is by Varian, which lists tubes delivering in excess of 100 milliwatts to 140 gc and 50 mw to 170 gc. Oki Electric of Japan has reflex klystrons between 30-100 gc. Amperex (Philips) has devices at 8, 4, 3.2 and 2.5mm, and Raytheon markets an extensive line with coverage to 120 gc in its QKK series. Litton Industries also markets several relatively high powered reflex klystrons in the 35, 50, and 70 gc ranges.

—High-powered cw tubes are described as either oscillators or amplifiers. Hughes lists BWO's delivering 15, 8, and 2 watts at 5.5, 3.2, and 2mm respectively. Litton markets the Elliott line of floating drift tube klystrons which operate in the 35-50 gc range, delivering 50 watts at 35 gc. Oki has two devices which deliver 10 and 2 watts. CSF has a device with 8 watts at 70 gc. Watkins-Johnson lists a 750-watt unit at 35 gc.

—Among the amplifiers, Hughes has three traveling-wave-tube units that deliver 150 and 1,200 watts at 5.5 mm and 150 watts at 3.2 mm. Watkins-Johnson lists a 1-kw 35-gc device. ■

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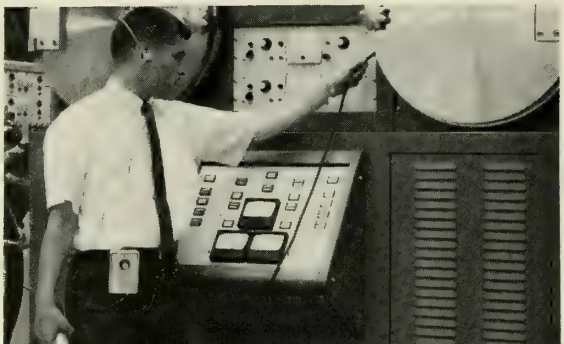
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New Product of the Week:

Portable Leak Detector



A portable leak detector for use in high and ultra-high vacuum systems has been developed by General Electric Co.'s Vacuum Products Operation. The battery-operated Audible Leak Detector can be clipped to the operator's belt and enables one man to check for leaks on the largest vacuum systems, the firm says.

The unit can be plugged into the recorder output of any pressure measuring device or ion pump control with an output between 0.1 and 1v. Detection does not require interruption of system operation.

The device operates by amplifying the difference between the pressure response of a probe gas sprayed over the leak and the characteristic pressure response of air. Difference is indicated to the operator by a change in audible tone transmitted through earphones. When used with the proper pressure gage under ultra-high vacuum conditions, leaks as small as 10^{-14} torr liters/second may be detected.

Different probe gases such as helium, argon or oxygen may be used with the detector, depending on the vacuum system being examined. In operation, the tone frequency is set at the low end of the detector's audio scale, which ranges from 100 to 2,000 cycles. A change of 100 cycles is immediately noticeable.

Circle No. 151 on Subscriber Service Card

Miniature Accelerometers

The Series 116 accelerometers with weights ranging from 1.3 to 2.8 grams is available from Wilcoxon Research. The units have sensitivities from 3 to 100 mv/g, depending on desired frequency response. They are available with integral studs, cement-on types and triaxial units.

Circle No. 152 on Subscriber Service Card

Differential Amplifier

General Instrument Corp.'s Semiconductor Products Group has available a microelectronic differential amplifier with a dc stability typically 5 mv/degree C and a common-mode rejection ratio typically 100 db.

The PC-201 employs seven silicon transistors, six multiple resistors and one capacitor. All are mounted on a ceramic substrate measuring approximately 0.57 x 0.325 in. The device has a single-ended open loop gain typically 73 db and a differential input of 200 kilohms. Operating temperature range is —55° to 125°C. Maximum electrical ratings include: power supply voltage, $+V_{CC}$, 25v; negative supply voltage, $-V_{EE}$, 25v; reference supply voltage, 25v; input voltage, 8v.

Circle No. 153 on Subscriber Service Card

UHF Motor-Generator Sets

A new line of Hertner UHF motor-generator sets has been introduced by Kearfott Div. of General Precision, Inc. The new generators are built in a single-unit, two-bearing package, in both vertical and horizontal models.

They produce single-phase and three-phase high-frequency output—2,000 to 19,000 cycles or higher—at ratings from 0.25 to 30 kva. Between one and four frequencies may be obtained from one generator.

Each 3,600-rpm. generating unit consists of an induction drive motor and high-frequency generator, constructed on a common shaft within an integral welded steel housing. The motor is designed for three-phase, two-pole, 60-cycle, 208-240 or 440-480v operation. The generator is a separately excited, multiple-pole unit, containing from one to four rotor stacks.

Circle No. 154 on Subscriber Service Card

Response Analyzer

Weston Instruments, Inc., is marketing the Model DA410 frequency response analyzer with response measurements from 0.0001 to 1,000 cps.

The unit provides direct digital readout of phase and amplitude. Automatic test methods result in 40 db of noise rejection. The solid-state unit weighs 38 lbs. and measures 7 x 17 x 16 in.

Circle No. 155 on Subscriber Service Card

Telemetry Transmitter

Sonex, Inc., is marketing a solid-state telemetry transmitter featuring FM 10-watt output and a frequency stability exceeding ±0.005%.

The TEX–3910 transmitter has a frequency range of 215 to 260 mc. Power output is 10 watts nominal and input is 28v at approximately 1 amp. The unit has an operating temperature range of –20° to 85°C and is also available in a range from –55° to 110°C.

Circle No. 156 on Subscriber Service Card

Crystal Oscillator

A plug-in, packaged crystal oscillator for space, airborne or ground application has been developed by Electronics Div. of Bulova Watch Co.

The PCO2HP unit has a rated stability of ±5pp 10^9 per 24 hours at 1 mc. The oscillator unit is enclosed in a proportional control oven and includes a quartz crystal in a glass bulb for minimum aging rate, a Zener regulator and silicon semiconductors. Minimum operating life is 10,000 hours.

Specifications include an output of 1v peak-to-peak into a 4.7 k ohm load; oscillator power of 28v dc at 25 mc, and oven power of 28v dc at 6 watts at 25°C. The unit meets MIL–E–5400, –4970 and –5272 requirements.

Circle No. 157 on Subscriber Service Card

Component Testers

The Scannex series of electro-mechanical switching-solid-state control systems for programmed component testing and other applications is announced by James Cunningham, Son & Co., Inc. The systems offer a choice of four basic scanners ranging in capacity from 100 to 10,000 points.

Features of the Scannex include

BCD readout, providing position information for peripheral equipment using standard 1-2-4-8 weighting; internal clock ranging in pulse rates from 0.5 to 60 channels per second, and remote random-access operation mode and switching circuit protection. The slide-out crossbar switch has an operating life of at least 20 million operations.

Circle No. 158 on Subscriber Service Card

Digital Voltmeter

Measurement and display of electrical or physical data as a statistical plot is possible with the Model SV4 statistical digital voltmeter being marketed by Non-Linear Systems, Inc.

The SV4 is designed for automatic measurement and statistical classification of data in mass production, quality control or engineering and scientific application. It can statistically plot electrical measurement directly or plot physical quantities such as temperature, thickness, length, weight, stress, pH and speed.



Voltage range of the unit is from 1 mv to 1,000v with an accuracy of ±0.1%. Reading rate is 3 per second and vertical scale is adjustable to 20, 50 or 100 signals within a class for full scale indication.

Circle No. 159 on Subscriber Service Card

Desoldering Iron

A pencil style desoldering-resoldering iron for work on miniature components on printed circuit boards has been announced by Enterprise Development Corp.

The Model 300 is a complete tool that permits one-hand operation. It is 8 in. long and weighs 3.5 oz. The unit is rated 40 watts at 115v and delivers a 720° tip temperature. Tips are available in five sizes, 0.08 in. being standard.

Circle No. 160 on Subscriber Service Card

Temperature Chamber

A new Mini-tray chamber has highly controllable high- and low-temperature facilities for life and aging tests of components such as diodes, transistors, resistors and chokes in small quantities. It has been developed by Associated Testing Laboratories, Inc.

The chamber measures 8″ high x 10″ wide x 11″ deep, and is fitted with a single component tray. It can energize and take measurements on as many as 50 components during testing in the temperature range of −100°F to 350°F with control accuracies to ±2°F or ¼ °F. Forced warm air circulation through the tray door exterior panel prevents moisture build-up on the connector wires while testing at low temperatures.

Circle No. 161 on Subscriber Service Card

Test System Series

Tektronix, Inc., has developed the X-3000 series of systems, designed to make switching time measurements on integrated microcircuit logic modules, transistors and related packages.

System configurations center around the Type 567/6R1A digital readout oscilloscope, which provides display of the parameter being measured and analog/digital conversion of the reading. The systems basically consist of five functional sections: programming, driving sources, test fixtures, waveform analyzer and data recording.

Circle No. 162 on Subscriber Service Card

Resistivity Measurer

A measurement system to determine specific resistivity of semiconductor blanks has been announced by Cimron Corp.

Operating with a customer-specified probe, the Model 253 will indicate specific resistivity directly in ohms/cu. cm. with 5-digit resolution. The current source is digitally programmed to supply correct currents for specimen thicknesses of 3 to 15 milli-in. Controls eliminate the effects of thermal voltages, photo injection and variations in probe spacings. Repeatability of the system is better than 0.1%.

Circle No. 163 on Subscriber Service Card

Strip Transmission Line

A new air-dielectric strip transmission line with integrated components has been introduced by the electronic division of Electronic Specialty Co.

Applications for air-line include duplexers, radar front ends, mixers, test sets, and plug-in microwave modules. Air-line has a weight savings up to a factor of 10, elimination of RF leakage, no spurious modes, and simple installation and maintenance.

Circle No. 164 on Subscriber Service Card

Polonium Static Neutralizer

A static neutralizer employing the ionizing isotope polonium 210 is announced by Nuclear Products Co. The Staticmaster Ionizing Unit Model 2U-500 with Positioned Model BF1 is designed for use where the presence of static electricity causes instrument inaccuracies and material handling problems.

The device utilizes alpha radiation to neutralize static and consists of a 500-microcurie polonium sealed source mounted in a stainless steel case with a protective metal grid. The alpha radiation emitted by the polonium is non-penetrating and harmless externally.

Circle No. 165 on Subscriber Service Card

Miniature Terminal Boards

Cambridge Thermionic Corp. has introduced a new miniature terminal board featuring forked terminals that permit components to be placed directly into the terminal for easy soldering and rapid assembly in volume production.

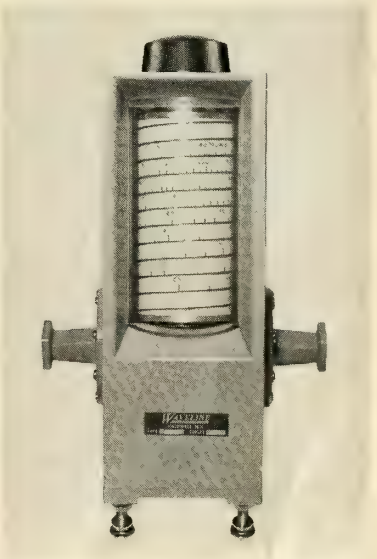
Only 1/16″ thick, these miniature terminal boards consist of individual segments, each 1 15/16″ long. Boards of up to five segments can be supplied in glass epoxy, paper-base phenolic or cotton-fabric phenolic. Board widths are 5/16″, 7/8″ and 1 1/8″.

Circle No. 166 on Subscriber Service Card

Precision Attenuators

Waveline., Inc., has available a series of direct reading precision attenuators covering the frequency range of 3.95 to 40.0 gc in seven standard models.

The units provide varying attenuation from 0 to 60 db over the full wave-



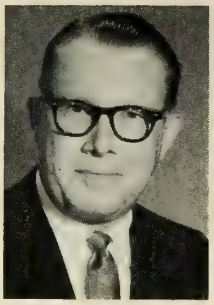
guide operating frequency range. Accuracy of reading is ±2% of the db reading or ±0.1 db, whichever is greater, from 0 to 50 db; accuracy is ±3% of the db reading from 50 to 60 db. Insertion loss at 0 db setting is less than 1.0 db; VSWR is less than 1.15.

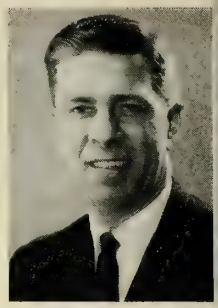
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FLICEK


DOBBS


FORDYCE


CURTIS


WEBER

Dan W. Burns: Appointed president and a director of the Electrada Corp., Culver City, Calif. He was formerly vice president in charge of Defense Systems Operations for Lear Siegler, Inc.

Col. Jerry F. Flicek: Former Commander of the Churchill Research Range, a unit of the Air Force Office of Aerospace Research, has been named commander of the 6596th Instrumentation Squadron (AFSC), Vandenberg AFB, Calif. He has been closely involved in the missile research field for 16 years.

Herbert S. White: Appointed director of the Scientific and Technical Information Facility, Documentation Inc., Bethesda, Md., for NASA. He was previously with IBM.

Edward Brinton Morrow: Resigned as vice president, chairman and member of the Finance Committee, and as a member of the Board of Directors of Hercules Powder Co., Wilmington, Del. He is retiring after 48 years with Hercules.

Paul R. Vogt: Appointed vice president and general manager of the Space Engines Div. of Rocketdyne, Canoga Park, Calif., a division of North American Aviation, Inc. He has worked primarliy in the development of liquid rocket engines.

Guy Dobbs: Appointed assistant director of the Technology Directorate of System Development Corporation's Research and Technology Div., Santa Monica, Calif. He also serves as the acting head of the directorate's advanced information processing technology staff.

Robert C. Fordyce: Named general manager of the new Hergenrather Personnel Bureau, Los Angeles, a firm spacializing in assisting aerospace-oriented companies place men and women in junior executive and middle management positions.

Gordon H. Smith: Named chief scientist for Autonetics, a division of North American Aviation, Inc., Anaheim, Calif., Strike Avionics Div. Prior to assuming his new position, he was assistant chief engineer for Autonetics' Data Systems Div.

George Stoner: Has been named assistant Aerospace Div. manager for launch and space systems at The Boeing Co., Seattle. He is also a vice president and has directed Boeing's work on the *Saturn V* launch vehicle for the past three years.

D. Ross Brown: Appointed president of Astek Instrument Corp., Armonk, N.Y. He will be responsible for all operations of the firm, which designs and manufactures air-mass data systems and components for military and commercial aircraft.

Eugene R. White: Appointed manager of hydrocarbon fuel cell programs for the direct energy conversion operation at General Electric, Schenectady, N.Y. He is responsible for continued development of fuel cells.

Daniell L. Dailey: Appointed director of marketing services for the Electronic Industries Association, Washington, D.C. He is manager of market planning for the United Aircraft Corp., East Hartford, Conn.

John F. Jewett: Appointed manager of the AN/MPQ-32 weapons-locating program at Sylvania Electric Products Inc., a subsidiary of General Telephone & Electronics Corp., New York City.

William R. Ellis: Appointed manager of NERVA materials and fuel for the Westinghouse Astronuclear Laboratory, Pittsburgh.

Robert Paul: Appointed technical manager of the commercial applications department of Computer Sciences Corp., Los Angeles. He will direct all projects in the commercial field.

J. Curtis Counts: Appointed vice president-employee relations, Douglas Aircraft Co., Santa Monica, Calif. Also named was **Edward Curtis** to the post of vice president-administration and contracts.

Andrew J. Rebmann: Elected executive vice president of Veeder-Root Inc., Hartford, Conn. He has been a vice president since 1954 and a director since 1958.

John M. Ward and Walter O. Weber: Elected vice presidents of Haveg Industries, Wilmington, Del. Ward is in charge of the Sil-temp Div. and Weber is in charge of the Research and New Products Div.

Alvin B. Phillips: Named to the newly created position of general manager of integrated circuits for the Semiconductor Div. of Sylvania Electric Products Inc., New York City.

Alvin W. Ray: Promoted to senior executive vice president of ITT General Controls Inc., Van Nuys, Calif. Also, **Richard A. Ray** was promoted to executive vice president of ITT General Controls.

Nicholas G. Fanos: Appointed assistant to the president and member of the board of Kahn and Company, Inc., Wethersfield, Conn. Kahn is an engineering research and development firm.

Harold H. Hall: Appointed to the newly created position of chief scientist for the Director for Remote Area Conflict, (Project AGILE), Advanced Research Projects Agency.

Raymond F. Wulfe: Appointed manager of Applications Engineering by Microwave Physics Corp., Garland, Tex., a subsidiary of Melpar, Inc. He will coordinate parametric amplifiers, Ferrite and YIG devices, panoramic receivers and microwave components and subsystems.

John A. Vaughan: Appointed vice president, research and development of the Maxson Electronics Div., Maxson Electronics Corp. Maxson specializes in ordnance, missiles, navigation and anti-sumarine warfare equipments and systems.

Richard A. Montgomery: Has rejoined The Boeing Co., Seattle, as director-military systems in the Aero-space Div. after having served more than two years with the Department of Defense.

John C. Hamaker, Jr.: Elected to the board of directors of Vanadium-Alloys Steel Co., Latrobe, Pa. He is presently vice president-technology.

Arthur J. Holub: Will head the electronics department of Maremont Corp., Research Div., Pasadena, Calif.

Morton A. Maurer: Named vice president of Ventura Div. of Northrop Corp., Beverly Hills, Calif., He was formerly manager of production operations at Ventura.



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—when and where—

SEPTEMBER

International Conference on Magnetism, sponsored by the International Union of Pure and Applied Physics and the British National Committee for Physics, Nottingham, England, Sept. 7-11.

International Conference on Microwaves, Circuit Theory and Information Theory, IECE of Japan and IEEE, Tokyo, Japan, Sept. 7-11.

Fifteenth Congress, International Astronautical Federation, sponsored by the IAF, Warsaw, Poland, Sept. 7-12.

British Aerospace Companies' Flying Display and Exhibition, Farnborough, Hampshire, England, Sept. 7-13.

Air Force Association National Convention and Aerospace Development Briefing and Displays, Sheraton Park Hotel, Washington, D.C., Sept. 9-11.

National Power Conference, IEEE and ASME, Mayo Hotel, Tulsa, Okla., Sept. 9-11.

Twelfth Annual Engineering Management Conference, sponsored by the IEEE, ASME, AIIE, ASCE, and others, Pick-Carter Hotel, Cleveland, Sept. 9-11.

Advanced Incentive Contracting, sponsored by the National Defense Education Institute, Boston, Sept. 9-11.

54th National Meeting of the American Institute of Chemical Engineers, Flamingo Hotel, Las Vegas, Sept. 13-16.

Eighth International Convention on Military Electronics, sponsored by the IEEE, Shoreham Hotel, Washington, D.C., Sept. 14-16.

Symposium on Mass Spectrometry sponsored by the Group for the Advancement of Spectrographic Methods, Paris, Sept. 14-18.

World Conference on Radio Meteorology sponsored by the American Meteorological Society, National Bureau of Standards, Boulder, Colo., Sept. 14-18.

Techniques of Value Engineering for Defense and Space Contractors, sponsored by the National Defense Education Institute, Washington, D.C., Sept. 14-18.

First International Cellular Plastics Conference sponsored by the Cellular Plastics Div. of the Society of the Plastics Industry, Inc., Barbizon Plaza Hotel, New York City, Sept. 14-18.

"Modern Engineering Applications of Computers," a course sponsored by Control Technology, Inc., Edgewater Inn, Long Beach, Calif., Sept. 14-18.

49th Norelco X-Ray Analytical School sponsored by Philips Electronic Instruments, Sir Francis Drake Hotel, San Francisco, Sept. 14-18.

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The Red Dilemma

A RECENT DISPATCH from Moscow sheds interesting light on a military strategy debate now going on within the Soviet Union.

The Associated Press reports that two high-ranking Soviet military officers are continuing their dissent from Premier Khrushchev's defense policies, notably objecting to cost-cutting and to alleged overemphasis on nuclear strategic missiles.

The two officers are Marshal Vasily Sokolovsky, former chief of the Soviet General Staff, and Maj. Gen. M. Cherednichenko. Their views appear in the Defense Ministry paper *Red Star (Krasnaya Zvezda)*. As the AP notes, the discussion is continuation of a dispute touched off two years ago by the book "Military Strategy," which was written by Sokolovsky and a number of other Soviet military experts.

To over-simplify the dispute, Marshal Sokolovsky and others are concerned that more conventional land, sea and air forces are being neglected in the emphasis on nuclear missiles, strategic and tactical.

From the other side, Premier Khrushchev's attitude is a familiar one: there are limits to what can and should be spent on defense. With the growing pressure for higher standards of living—a demand which is being met—it becomes increasingly more difficult for the Soviets to fund all those projects which military officers consider desirable.

But beyond that rises a question of military strategy similar to the one now being debated in the United States. In today's nuclear balance of terror, can a nation afford to neglect its tactical, conventional arms?

There undoubtedly are as many pressures in the Soviet Union today for development of new and advanced manned aircraft as there are in this country. And, as in this country, some are being met, some are being turned aside.

The similarity of the problem facing the two nations is more than coincidental. Both the U.S. and the USSR looked down the nuclear barrel during the Cuban crisis. Both since have recoiled from what they saw there.

In addition to leading to more searching efforts for peaceful co-existence, this also has brought a stronger requirement for conventional weapons in order that conflict, if inevitable, can occur further down the escalation scale—without the need for a quantum jump to nuclear weapons in brushfire situations.

But for the United States, the problem is a simpler one. This nation has not only a sizeable fleet of strategic aircraft but formidable strength in *Atlas*, *Titan* and *Minuteman* ICBM's, together with a growing force of *Polaris* submarines.

Nearly all of the U.S. land-based missiles are in hardened and dispersed silos.

Secretary of Defense McNamara has placed the U.S. superiority in manned bombers at 4 to 1. He estimates intercontinental ballistic missile superiority at the same figure, crediting the Soviet Union with fewer than 200 ICBM's and fewer still in hardened silos. U.S. operational ICBM strength now stands at more than 800.

The sea-going comparison is even more one-sided. The U.S. has 256 *Polaris* missiles deployed aboard 16 submarines. These are missiles of 1,500-mile range or more; they can be fired from beneath the surface; all are carried aboard nuclear-powered subs. By contrast, Secretary McNamara credits the Soviet Union with only 142 sea-going missiles with ranges of less than 500 miles. These cannot be fired from below the surface. Only a few Soviet subs have nuclear power.

THE PROBLEM for the Soviet Union, and the cause of the current military debate there, becomes apparent from these figures. They also explain why the problem is a more complex one for the Soviets than for the U.S.

The U.S. has in being a formidable strategic force. While it must maintain a considerable research and development effort aimed at improving and eventually replacing this force, it nevertheless now can devote a considerable portion of its defense budget to tactical, conventional forces.

The Soviet Union does not have this luxury. If Premier Khrushchev is to have anything even remotely matching U.S. strategic power, he must continue to pour billions of rubles into land and sea-based strategic systems. To devote the attention to conventional land, sea and air forces which Marshal Sokolovsky is demanding would require a drastic increase in the Soviet defense budget.

But to place this added defense burden on the Soviet economy is not an easy decision to make. At this stage in the nation's development, funds are needed for other vital projects—for agriculture, for a build-up in electronics, for development of the chemical industry and to provide better housing, better clothing and the other improved living standards which the Soviet people desire.

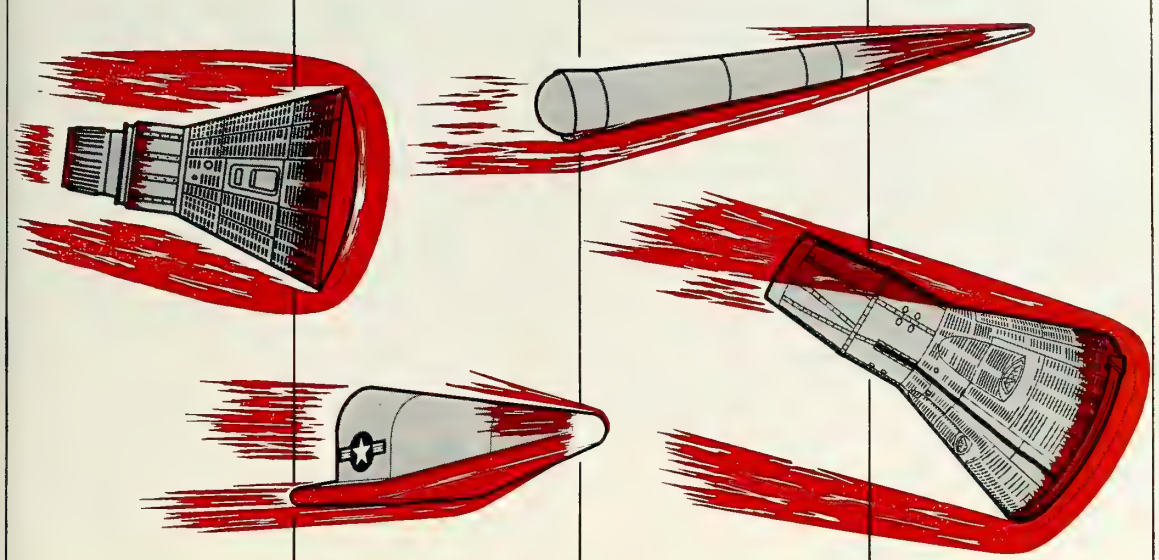
There are many side-effects of these conflicting pressures. The slow-down in Soviet ICBM deployment may be one. This could be attributable not only to a lack of all-out funding but to Premier Khrushchev's realization that small, cheap solid-fuel ICBM's of the *Minuteman* type are more attractive both financially and strategically than the present clumsy liquid-fuel rockets. Since the Soviet chemical industry is one of the weak spots of the economy, it may be taking considerable time to develop these missiles, time that becomes an embarrassment in the face of the demand for funding of conventional forces.

Add to these pressures the urgent needs for anti-missile missile and antisubmarine warfare forces and the size of the problem confronting the Soviet premier becomes apparent. The arguments of Marshal Sokolovsky for a new approach to conventional warfare carry considerable weight in these circumstances—and tend to confirm the direction in which the U.S. Defense Department now is moving. The market implication for U.S. industry is obvious.

William J. Coughlin

EARTH ORBITAL REENTRY

Four spacecraft programs, each engineered to explore diverse techniques for earth orbital reentry, are underway at McDonnell.



MERCURY

MERCURY, America's first manned orbital spacecraft, utilizes a non-maneuverable ballistic reentry. After retro-rockets slow the spacecraft to bring it out of orbit, reaction jets position it for reentry. Mercury's ballistic shape maintains alignment with the drag vector as it follows a ballistic path through the atmosphere to drogue chute deployment at 21,000 feet. Final descent to an ocean landing is accomplished with a 63-foot ring-sail parachute.

ASSET

ASSET, an instrumented, unmanned, winged vehicle, will reach speeds of 13,000 miles per hour in sub-orbital flights at altitudes of over 40 miles. This space research program will provide for study of glide reentry technology, refractory materials fabrication experience, and accelerate the development of maneuverable reentry techniques. A parachute landing system enables recovery of vehicle and data package for post flight analysis of test data.

AEROBALLISTIC

AEROBALLISTIC is a word coined to describe the lifting body concepts proven by flights of McDonnell hypersonic missiles from Cape Canaveral in early 1959. The test flights demonstrated precise atmospheric control, the aerodynamic efficiency of an Aeroballistic vehicle and were the first breakthroughs in the design of maneuverable reentry spacecraft. Space missions utilizing an Aeroballistic type vehicle would terminate with a conventional runway landing.

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GEMINI is a two-man orbital spacecraft for long duration and rendezvous missions. Upon reentry, the crew will position Gemini's off-set center of gravity with attitude control jets to re-orient the drag vector and create a lift component. This lift will enable the crew to maneuver Gemini to any point in a 28,000 square mile landing area. A paraglider will be deployed in later flights, enabling precise astronaut control of the glide to the landing field.

With MERCURY, ASSET, AEROBALLISTIC and GEMINI Spacecraft, McDonnell is perfecting reentry techniques, shapes, materials and manufacturing processes necessary for the achievement of U. S. leadership in space.

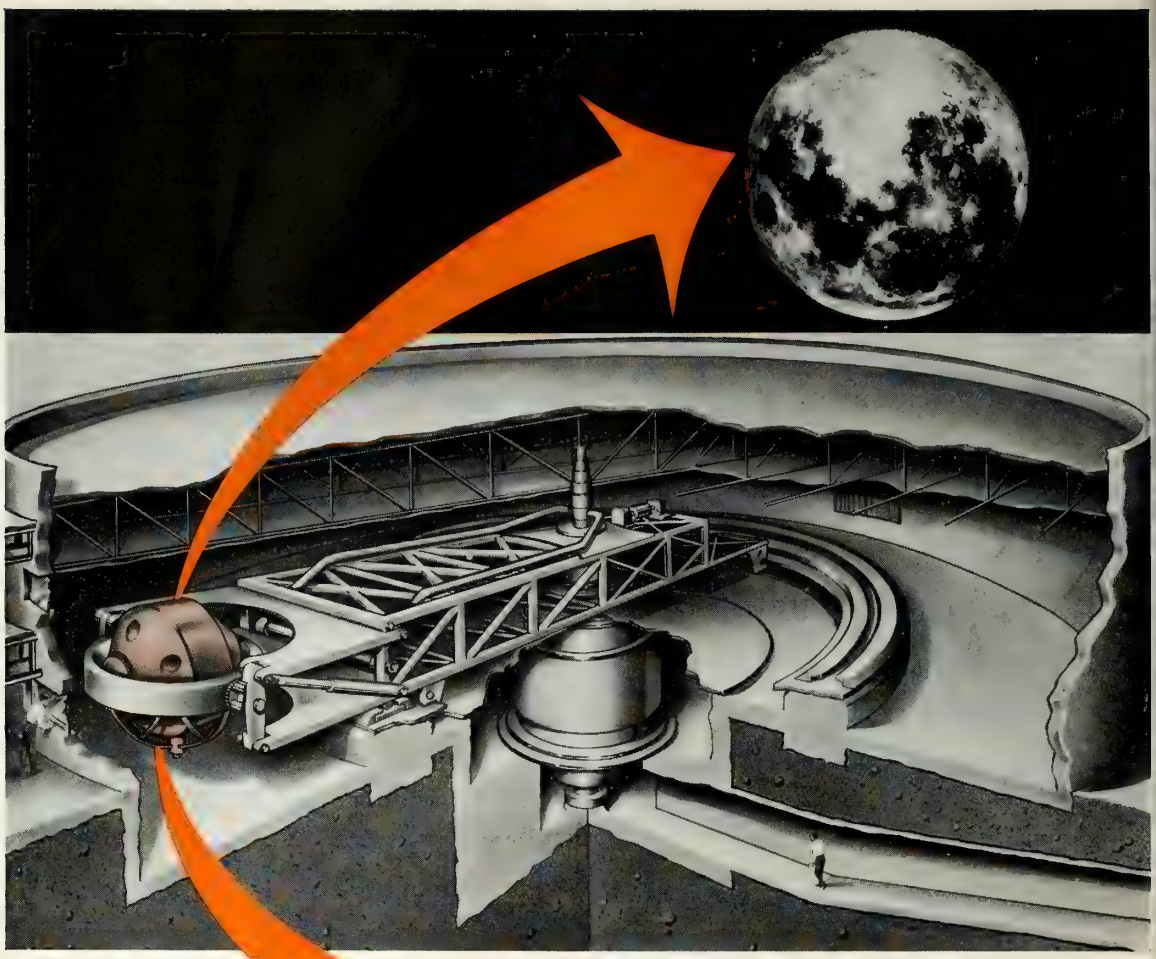
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- *Mercury and Gemini are being designed and built by McDonnell for NASA under the technical direction of the Manned Spacecraft Center.*
- *Asset is being developed and built under the sponsorship of the Aeronautical Systems Division of the Air Force Systems Command.*
- *Aeroballistic vehicles were developed and tested under contract with the U.S.A.F.*

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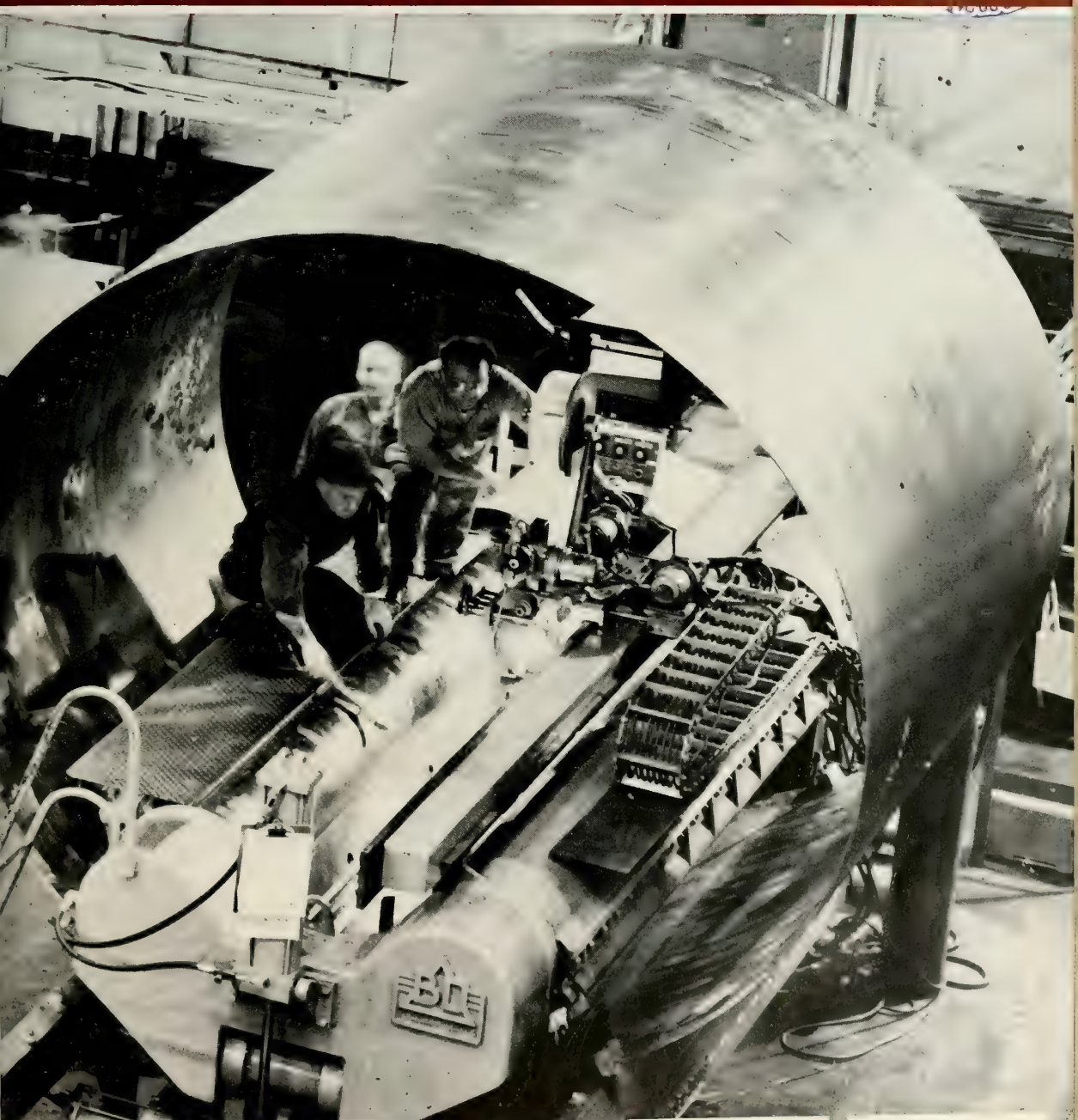
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missiles and rockets

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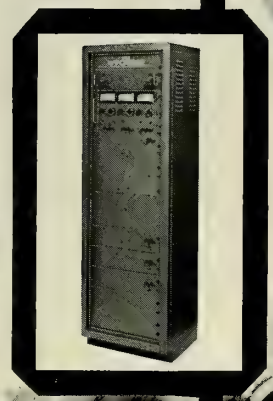
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COMPARE magnetic fields with a closed-loop control console that applies a calibrated reference current to the reference winding of the probe so an induced, comparable magnetic field is developed about a probe element.

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The Dycome System consists of a 3-axis, flux-gate magnetometer probe, a control console, and a 3-axis Helmholtz coil eight feet in diameter. You can install it almost anywhere; it doesn't require a shielded room. It will automatically compensate for changes in ambient field disturbances to provide a constant, precise and uniform magnetic field of any desired magnitude. As we say, it's dynamic. Its solid state feedback circuitry provides minimum drift operation. It is used in aero-space studies and to test and calibrate magnetic instruments. It is also used for paleomagnetic and geomagnetic field research, and to study electron beam deflection systems. It has many other applications. And it has these performance characteristics:

Accuracy: The field in the working volume will not deviate from the set point by more than 2.0 milligauss for variation in the ambient magnetic field up to ± 600 milligauss.

Response: Down 3 db. at 10 cps.

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Field Control Range: + 600 milligauss to — 600 milligauss.

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Power Requirements: 60 cycles or 400 cycles.

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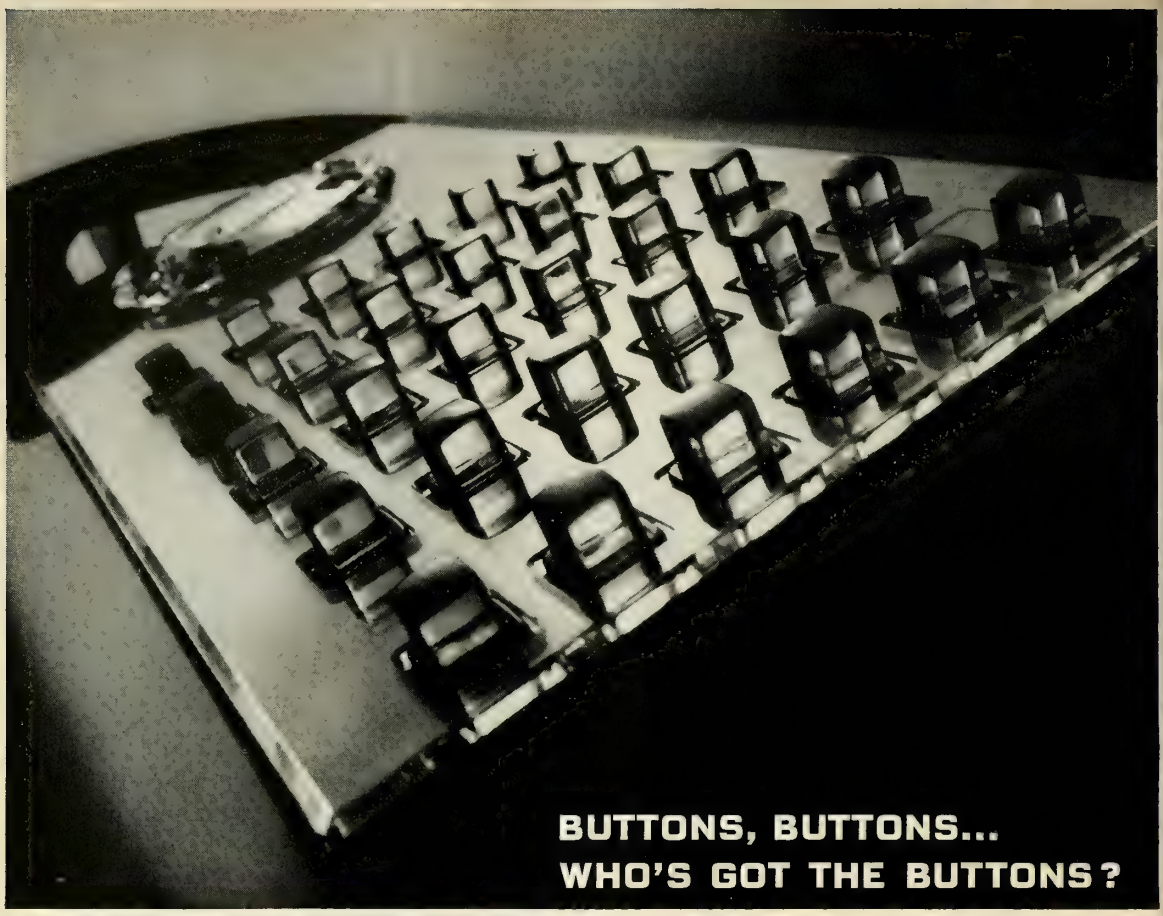
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THE WEEKLY OF SPACE SYSTEMS ENGINEERING

Volume 15, Number 11 September 14, 1964

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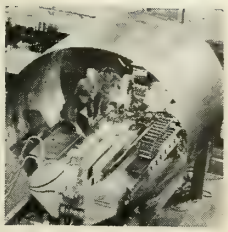
Published each Monday with the exception of the last Monday in December by American Aviation Publications, Inc., 1001 Vermont Ave., N.W., Washington, D.C. 20005. Cable Address: AMERAV.

Printed at Judd & Detweiler, Inc., Washington, D.C. Second class postage paid at Washington, D.C.
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Subscription rates: U.S. and Possessions, Canada, and Pan American Postal Union Nations: 1 year, $5.00, 2 years $8.00, 3 years $10.00. All other foreign: 1 year $15.00, 2 years $25.00, 3 years $35.00. Air freight to Europe: 1 year $20.00, 2 years $30.00, 3 years $40.00. Single copy prices: regular issues 50 cents each; special issues $1.00 each. Subscriptions are solicited only from persons with identifiable commercial or professional interests in the missile/space industry. Subscription orders and changes of address should be referred to Circulation Fulfillment Mgr., Missiles and Rockets, 1001 Vermont Ave., N.W., Washington, D.C. 20005. Allow 4 weeks for change to become effective and enclose recent address label if possible.

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THE COVER



An automatic welding head moves down a longitudinal seam in fabricating a center segment for the 120-in. Titan III strap-on solid booster case at Westinghouse Electric Corp. The Ladish D6AC steel plate is firmly held in the fixture and precisely positioned to avoid mismatch. *See p. 32.*

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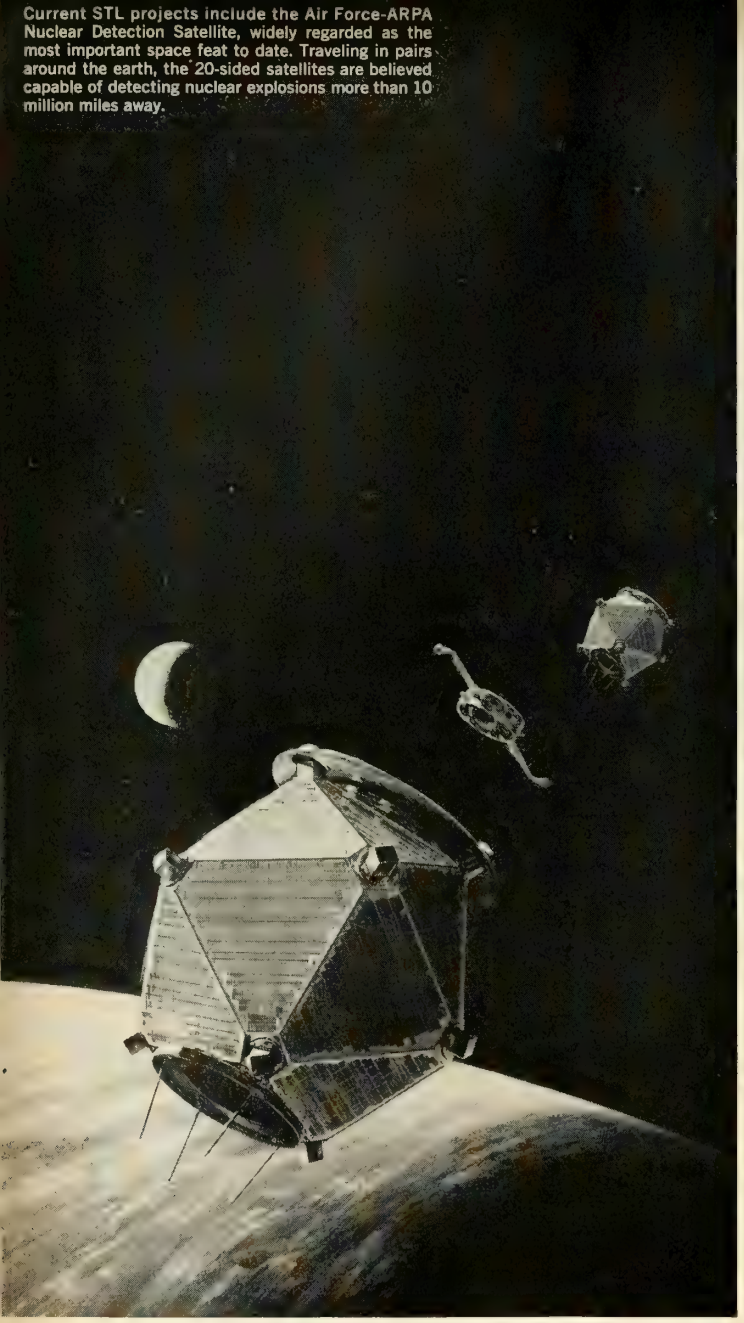
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Current STL projects include the Air Force-ARPA Nuclear Detection Satellite, widely regarded as the most important space feat to date. Traveling in pairs around the earth, the 20-sided satellites are believed capable of detecting nuclear explosions more than 10 million miles away.







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Within this beautiful $32 million building complex at Redondo Beach near Los Angeles, TRW Space Technology Laboratories carries out major aerospace projects from blueprint to black sky — from concept through launch. TRW Space Technology Center is the nation's first facility expressly designed for the research, development, and manufacture of spacecraft and space systems.





(Left) Critical guidance equations for most of America's space probes were calculated in the computer area. Johnson temperature and humidity control protects the costly equipment.

(Center) A Johnson System provides pinpoint control of thermal conditions in "clean" rooms and laboratories. Over 200 people work in this 14,000 sq. ft. "clean" room.

(Right) All buildings at the Center are Johnson equipped. Now 60% completed, it will ultimately contain 10 buildings costing some $50 million.

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This 10-building Center, of which six buildings are now completed, is considered by the architectural and engineering firm of Albert C. Martin and Associates as one of its most challenging assignments and most successful achievements.

Accurate temperature and humidity control is, of course, essential throughout the Center. To meet its varied requirements, each building is equipped with a specially engineered Johnson Automatic Control System. Whether it's a research laboratory, the 14,000 sq. ft. clean room, an executive office, the computation and data reduction center, or a high-bay manufacturing area, Johnson Control assures utmost reliability in maintaining an optimum thermal environment.

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letters

On Criticizing Ranger

To the Editor:

Ranger program defender David E. Shaw's letter published in your Aug. 24 issue seems to question the intelligence and wisdom of criticizing six *Ranger* failures. First, I think Jet Propulsion Laboratory should consider itself fortunate that NASA had sufficient patience and funds to permit seven tries for success. As a taxpayer, I think I would have stopped "shelling out" long before seven. Let's face it—six failures are not wiped out by one success, nor does it wipe out the $150-million failure. *Ranger VII* may have been an unqualified $50-million success, but why couldn't we have had it on the first two or three launches?

Mr. Shaw asks "Where else can the nation obtain such genuine dedication and zeal in the achievement of excellence?" Well, just to name three with a better batting average than one in seven, I can recall RCA with *Tiros,* AT&T with *Telstar,* and Hughes with *Syncom.*

Finally, Mr. Shaw asks, as a result of the *Ranger VII* success, "who should be investigated now?" May I point out that it is the failures that cost us money—not the success? May we continue to have editors, Congressmen, and taxpayers who will question continued failures and ask *why.*

Lester J. Martin
Santa Ana, Calif.

Conax and Ranger VII

To the Editor:

We at Conax are proud and honored; proud to have served as part of the *Ranger* team to accomplish the task of obtaining photographs of the Moon, honored by the mention of our corporation as part of this task force in MISSILES AND ROCKETS' Aug. 10 editorial.

I think it is appropriate to say that only once before in history have so few done so much for so many, since I am sure we will all agree that the result obtained by this mission will have a drastic and dramatic effect on man's future life.

Felix G. Masci
Manager, Technical Staff
West Coast Office
Conax Corporation
Encino, Calif.

Film Readers

To the Editor:

We have noticed in your Aug. 17 issue (p. 17) a reference to the PFR-1 Programmable Film Reader, currently being used to read and digitize large quantities of film representation radar A-scope traces at Holloman AFB, N.M. This equipment is not manufactured by M.I.T., as your article stated but rather by Information International, Inc., 200 Sixth St., Cambridge, Mass. It is true that an original breadboard model of this equipment was developed for M.I.T. Lincoln Laboratory, but they have had no further connection with the development of the Programmable Film Reader since that time.

Incidentally, we have recently developed a new high-precision model PFR-2 Programmable Film Reader. This combines, for the first time, fully automatic high-speed film reading with a very high degree of resolution. Film reading measurements are accurate to 0.0002 inch, or about 5 microns.

The PFR-2 has been developed for the analysis of billionth-of-a-second events recorded on film during nuclear explosions, consisting of electrical transients of several thousand megacycles bandwidth recorded as oscilloscope traces. The high speed and high resolution of the system make it well suited for rapid automatic reduction of astronomical star charts, satellite tracking and other similar applications.

Edward Fredkin
President
Information International, Inc.
Cambridge, Mass.

Pro Forma Defense

To the Editor:

Your pithy editorial on "Alice in McNamaraland" (M/R, Aug. 3) highlights the *pro forma* policy which has proved very costly to the United States, as evidenced by the cases of Dr. Goddard, Simon Lake, Gen. Billy Mitchell, and Walter Cristie, just to name a few.

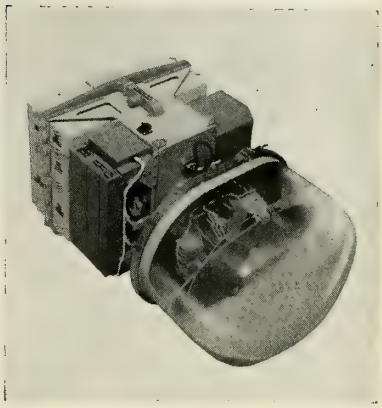
As a matter of comparatively recent record, were it not for the sterling character and dedication of Dr. Eugene P. Wigner of Princeton University, who challenged the opinion of Col. Adamson ("The Einstein Letter That Started It All," *New York Times Magazine,* Aug. 2), atomic developments would have been delayed, with consequent disaster for our country.

Specific defense requirements are but minor as compared with the tremendous flow of inter-disciplinary knowledge derived from the comprehension of atomic structures and displacements thereof. Therefore, under the present circumstances, there appears the need for a new civilian board, other than the National Inventors Council, of non-academic inventors including Benjamin F. Miessner and others as well as university-oriented scientists, to superintend and meet immediate and rising needs of our various defense departments with dispatch and without the delays occasioned by the *pro forma* policy which encourages overcomplication and provides time intervals for foreign inventors to render U.S. developments obsolete.

It should be obvious that the defense industry and the vast amount of new scientific knowledge emanating therefrom is not a WPA project, but the very hemoglobin in the blood stream of the United States.

Harry Bricker Fuchs
Farmingdale, L.I., N.Y.

And is this what most engineers mean when they say APPLIED MICROELECTRONICS?



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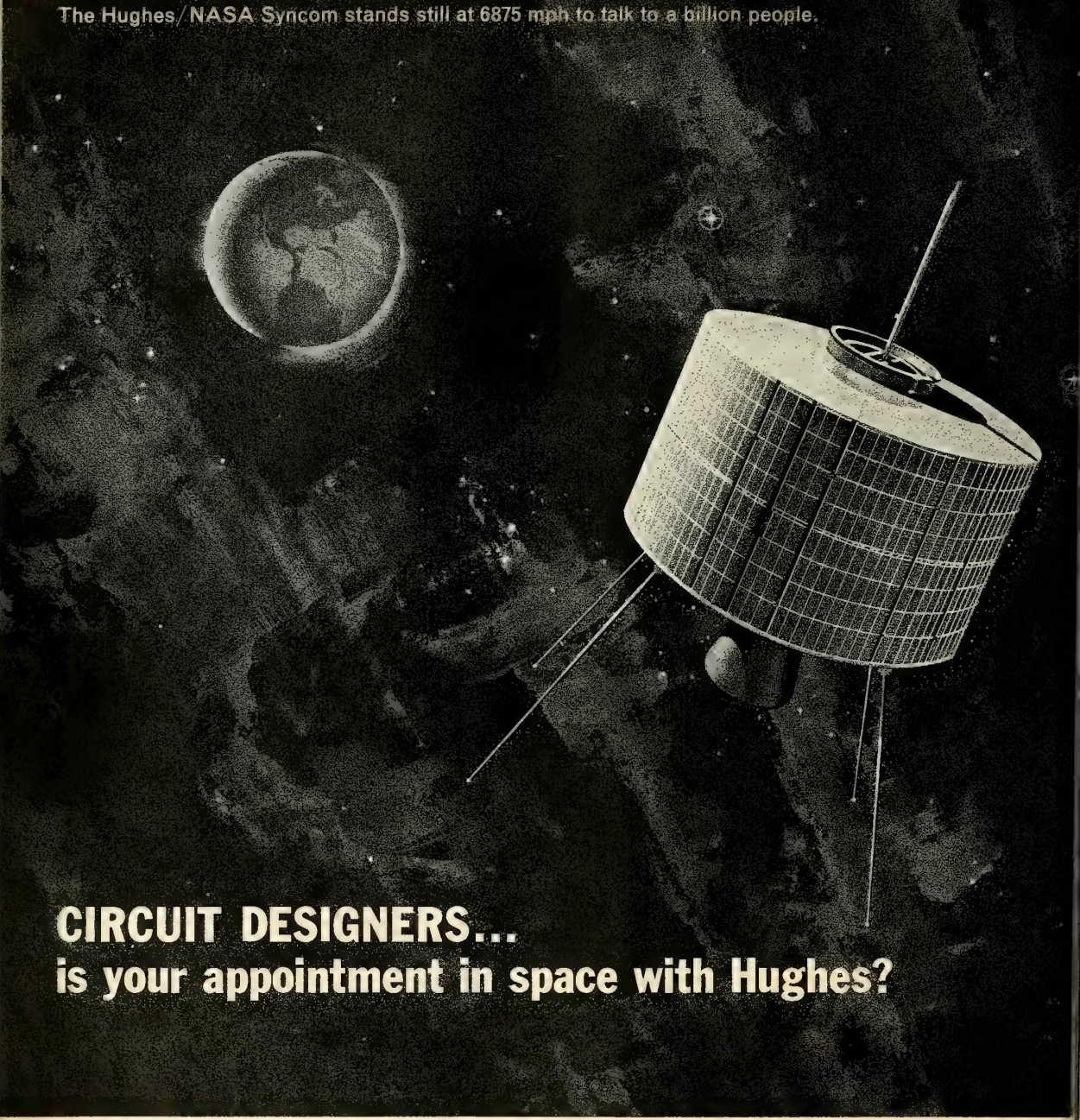
The R45 radar family was designed to fulfill a need for reliable, lightweight, easily maintained and versatile airborne systems at low cost. These building block systems weigh less than 100 pounds and have more than a 1000-hour inherent mean-time-between-failure rate in helicopter, transport and light attack applications. Basic K_u band frequency and 60 kw power can be varied to meet customer operational requirements.

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The Countdown

WASHINGTON

Joint Vehicle Report Delayed

The Special NASA-Air Force group studying a standard family of launch vehicles will not make its report to the joint Aeronautics and Astronautics Coordinating Board in mid-September, as had been expected. No new date has been set for the report, although the delay is not expected to be extensive. The group is evaluating sets of launch vehicles, assigning payloads and then comparing pricetags in an effort to aid the AACB in making a decision on future requirements.

Grumman Rumored Getting STEM Study

There are reports that Grumman Aircraft Engineering Corp. will shortly receive a $400,000 study contract on the so-called Stay Time Extension Module (STEM). The project, which would extend the Lunar Excursion Module's ability to remain on the Moon for up to two weeks, would be used in long-exploration lunar missions and as an aid in setting up a lunar base.

Some Potential Budget Victims

One project that may meet the budget-cutter's axe as a result of the approximately $73 million cut from NASA's Fiscal Year 1964 supplemental appropriations request is the Paraglider development program for *Gemini*. Other prospective casualties are a long list of backup systems and subsystems which the Office of Manned Space Flight had hoped to get started. Two other possibilities: stretching out of deliveries of later *Saturn IB* and *Saturn V* boosters, and the trimming of some ground-test models in *Apollo* spacecraft development. In the latter case, flight-rated vehicles would be used for ground testing.

Surveyor May Get Improved Retro

NASA is developing an alternate retro engine for the *Surveyor* spacecraft. It hopes to increase throttling range and reduce feed pressure requirements. The engine employs a variable-area injector coupled to a variable-area cavitating venturi control system. Incidentally, contrary to recent NASA reports, there are still seven Block I 2,150-lb. *Surveyor* vehicles in the program. The first four are engineering models that will carry only TV cameras. The last three will also carry scientific experiments.

Dora Causes Minimal Launch Troubles

Despite some delay forced by Hurricane Dora last week, space agency officials still hope to launch the fourth *Centaur* vehicle early in the fourth quarter of this year. Another launch which could be delayed by one to several days is the *Saturn SA-7* shot slated for this week.

Gemini Crew Training Advances

Flight crew members for the fourth *Gemini* mission—now expected in mid-1965—are beginning their training. At the same time, the crew for the third mission are switching to Cape Kennedy, where most of the rest of their training will be conducted. As a result of slippage in the second *Gemini* flight, Manned Spacecraft Center officials are expected in the near future to run an all-network check of their tracking stations.

Centers Get Bigger Checkbooks

NASA has increased the dollar ceilings for contracts which its centers may sign without headquarters approval. New limitations are: Wallops Station, $200,000; Headquarters Contracts Div., Kennedy Space Center, Electronics Research Center, Space Nuclear Propulsion Office and Western Operations Office, $1 million; and Ames Research Center, Langley Research Center, Lewis Research Center, Goddard Space Flight Center, Manned Spacecraft Center and Marshall Space Flight Center, $2.5 million.

INDUSTRY

'Hi-Dive' Rocket To Test Re-entry Parachutes

Space-General Corp. is building a new five-ton rocket vehicle to be used by the Air Force at El Centro, Calif., for testing recovery and re-entry parachutes for both manned atmospheric and space vehicles. Under an initial contract of $100,000, the vehicle, called "Hi-Dive," will be designed and built to be dropped from an aircraft at 45,000 ft., cut loose and fall free until stabilization parachutes halt it for firings of rockets that will speed it up to Mach 5. It would deploy its test parachute at 30,000 ft. Even if the chute failed to open, it would be recoverable and reusable. The Air Force says the delivery date for the first vehicle is expected next April.

GE Displays START Re-entry Vehicle Mockup

General Electric last week revealed its concept for a maneuverable re-entry vehicle to be flight-tested as part of the Air Force's Spacecraft Technology and Re-entry Test (START) program. A mockup of the Orbiting Maneuverable Re-entry Vehicle was displayed at the Air Force Association convention in Washington, D.C. It is shaped like a partially flattened sphere with tail fins. Outside surfaces would be covered with a silicon rubber compound acting as an ablation-type re-entry heat shield.

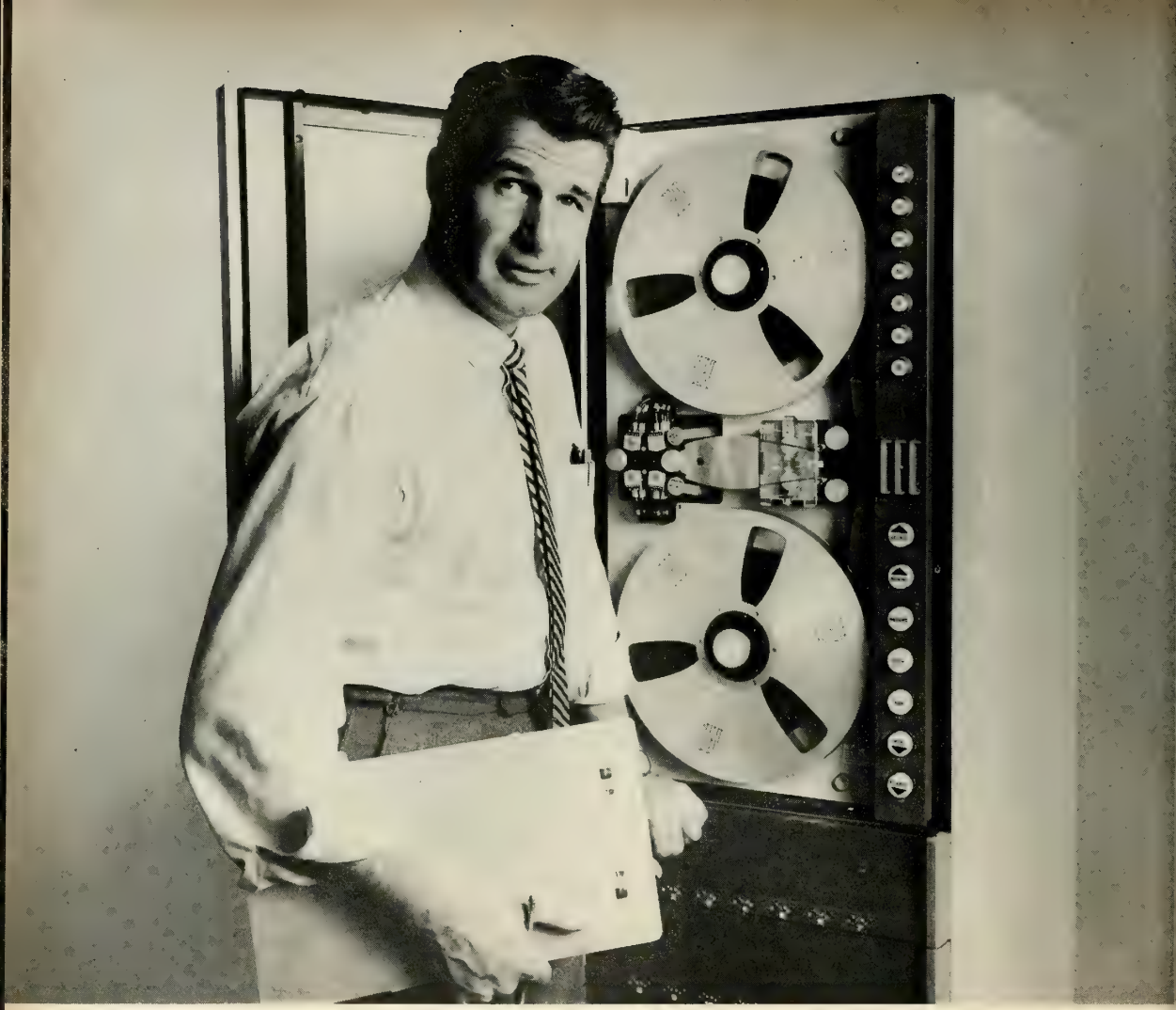
Douglas Making MOL, MORL Studies

Two aspects of spaceflight being studied by Douglas Missiles and Space Systems Div. with an eye to the Air Force's *Manned Orbiting Laboratory* and NASA's *Manned Orbiting Research Laboratory*. In one of the company-funded investigations, Douglas is using its 18-ft. centrifuge to determine how rotation may be used for cardiovascular conditioning in flight. It also plans a 60-day simulated space-station mission in a double-walled chamber.

INTERNATIONAL

Alouette Becomes a Magnetometer

Discovery of unexpected gyrofrequency ionic resonances in data transmitted by the Canadian topside sounder *Alouette* has opened up a new technique for measuring magnetic fields in space. Measurement of the frequency of any convenient harmonic of the resonance indicates the magnetic field strength in the volume of space around the satellite. *Alouette*, which was designed to measure electron densities in the upper atmosphere, can now be used to map the Earth's magnetic field.



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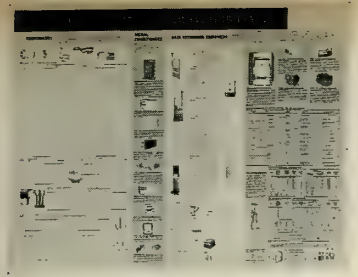


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Circle No. 7 on Subscriber Service Card

The Missile/Space Week

DOD Delays Industry Briefing

The Dept. of Defense has again postponed its series of "advanced planning briefings" for industry until after the 1964 elections.

Deputy Secretary of Defense Cyrus Vance has rescheduled the sessions, originally planned to open this week, until mid-February, 1965.

The briefings are sponsored by the National Security Industrial Association with the Assistant Secretary of Defense (Public Affairs) Arthur Sylvester coordinating DOD participation. The first session was to be in New York City Sept. 17 and 18, followed by briefings in Chicago, Dallas and Los Angeles in the next two months.

Spokesmen for the NSIA said the Pentagon argued that holding the briefings at this time might be construed as "partisan activity."

Reservations for the New York session had reached 1,267 before NSIA was notified of the cancellation, less than two weeks before opening.

U.S.-Canadian Missile Studied

Douglas Aircraft Corp. and DCF Systems Ltd. of Toronto, Canada, are considering cooperation on an anti-aircraft missile suitable for use on torpedo boats, frigates and other naval vessels, as well as for possible use by ground units.

According to the *Financial Post*, a Canadian business weekly, the two firms will meet next month to discuss the project. The proposed weapon is expected to find a good market among NATO countries, especially West Germany which has an anti-aircraft requirement for its Baltic P.T. boats.

No indication was given of government sponsorship by either nation.

The Canadian report said that Douglas would be responsible for actual missile development and DCF will act as systems manager for ground support equipment.

'Marginal R&D' Hit

The "fragmented character" of the U.S. research effort, particularly in regard to R&D work on missile/space power systems, was criticized recently by an industry leader.

Stanley C. Pace, equipment group vice president of Thompson-Ramo-Wooldridge, Inc., charged that "funding of marginal R&D programs deprives the most promising programs of the funds they need to achieve successful results."

Speaking at the AIAA Third Biennial Aerospace Power Systems Conference in Philadelphia, Pace predicted that when the manned spacecraft industry matures, power systems rated at 150 to 200 kw will be required for extended duration missions. No system rated at more than 1 kw has yet been flight-tested in the U.S. This lack of progress, he said, is primarily due to the tendency to broadly fund many questionable programs.

More regrettable, he says, is the fact that conclusions drawn from earlier expenditures of this nature have not curbed this tendency.

Pace called for the various government agencies to establish a strong coordinating mechanism for sharing information and planning R&D—all to be put into a single, long-range development plan.

A-3 Sub To Begin Patrol

The first U.S. Fleet Ballistic Missile Submarine armed with the *Polaris A-3* missile will begin its patrol this month, President Johnson told a news conference.

"I have been advised by Secretary of Defense McNamara that a new and significantly improved weapon—the *Polaris A-3* missile—will soon become part of our strategic missile force," the President said.

Sixteen of the 2,500-n.mi. missiles will go to sea on the USS Daniel Webster when it goes on station later this month. The *A-3*, the President said, was put under "accelerated development in 1964."

Polaris A-3 was actually operational in August with the successful completion of the flight test program. The missile, like its 1,200- and 1,500-n.mi. predecessors, is 31 ft. long and 54 in. in diameter and consists of two solid-propellant stages.

Both of the motor cases for the two stages are fiberglass with rotating nozzles to control the first-stage thrust and fluid injection to control the second stage. A new, smaller, more accurate inertial guidance system is also used in the *A-3*, coupled with an improved fire control system, it gives the missile a multiple-target capability.

Twenty-eight *Polaris* submarines will be armed with the *A-3* while the remaining 13 will retain the *A-2*.

RFD-2 Shot Slipped

Firing of the second Research Flight Demonstration (RFD-2) was rescheduled for Sept. 11 after two postponements caused by weather problems.

The capsule is to be launched aboard a *Scout* rocket on an 800-mi., suborbital trajectory from Wallops Island, Va., and impact at a point about 250 mi. southeast of Bermuda.

Objective of the Atomic Energy Commission program is to gain data on generator disassembly and fuel capsule burnup rate during re-entry. Martin Co.'s Nuclear Div. built the payload, a non-radioactive mockup of a 20-watt isotopic-thermo-electric generator.

RFD-1 was successfully fired over the same path in May, 1963.

New Satellites Successful

The space agency's three newest satellites, *Orbiting Geophysical Observatory* (*OGO*), *Nimbus* and *Syncom III*, are all performing successfully in space.

Officials reported that 19 of 20 experiments on *OGO* have sent data back to Earth despite the fact that the spacecraft failed to acquire the Earth shortly after it went into orbit. The problem apparently occurred when one of the booms was not fully deployed, thus obscuring the view of the horizon sensor.

OGO—launched Sept. 4—was orbiting the Earth with an apogee of 92,845 mi. and a perigee of 176 mi. Its orbital period was 64 hours.

Syncom III was scheduled to reach its stationary orbit slightly east of the International Date Line on Sept. 10. If successful, radio communication tests were to be attempted. No TV transmission will be possible until Oct. 1 when the required ground stations will be ready.

Nimbus, the heavy 830-lb. weather satellite, continued to transmit excellent pictures of Hurricane Dora as it moved toward the Florida east coast.

GE Division Gets New Chief

The General Electric Co. has named Richard L. Shetler general manager of its Defense Programs Div. in Washington, D.C.

In the new post, Shetler will be responsible for integrating and coordinating the company's field operations and customer services in the aerospace and defense areas. He will also head the company's planning and market analysis work for GE's Aerospace and Defense Group.

The Command Systems Div., which Shetler has headed, will be discontinued Sept. 15 when he moves into the new position and its operation reassigned to other divisions in an effort to focus business resources on serving the space, flight propulsion and electronics equipment needs of industry.

Realigned operations of the Command Systems Div. include:

Military Communications Dept., to the Defense Electronics Div.;

Apollo Support Dept. and Mississippi Test Support Operation, to the Missile and Space Div.;

Specialized military lines of the Communications Products Dept. will be transferred to the Military Communications Dept., with CPD moving to the Industrial Electronics Div. of the Industrial Group.

Shots of the Week

NASA on Sept. 4 launched the 1,073-lb. *Orbiting Geophysical Laboratory* from Cape Kennedy aboard an *Atlas-Agena* booster. *OGO* carried with it 20 scientific experiments (see p. 13).

- The space agency's *X-15* rocket plane was flown on a mission Sept. 3 carrying a "washboard" panel beneath its fuselage to determine if its rippled surface lessened air friction heating at ultrasonic speeds. Test

USAF Minuteman ICBM uses GLC Graphite in First Stage Rocket

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took place from Vandenberg AFB, Calif.

● As a prelude to the upcoming Biosatellite shot, NASA rocketed a white rat into space from Wallops Island, Va., on Sept. 3 aboard an *Arcas* sounding rocket.

Congress To Get Science Assist

A Science Policy Research Division to aid members of Congress in obtaining information on scientific and technical matters has been formed in the Library of Congress's Legislative Reference Service.

Dr. Edward Wenk, Jr. has been named to head the division, which goes into operation Sept. 28. The action is in direct response to recommendations made by members of the science and space committees of both houses.

R&D Distribution Revealed

California received 38.4% of Federal R&D money in the last fiscal year, a Congressional study not yet released reveals.

Rep. Emilio Q. Daddario (D-Conn.), chairman of the subcommittee on Science, Research and Development said in a speech that the unpublished study will confirm that California tops the list, with New York in second place with only 9.2% of the total. Third is Massachusetts with 4.6%, he said.

Daddario said that of the remaining states there is no large middle group of states that receive equal or nearly equal amounts.

On a per capita basis, Daddario said, California ranks only third. New York is below the national average in this respect. On this basis, distribution of R&D dollars produce less variation among states.

If the picture is viewed on the basis of dollars per industrial employee, Nevada leads with $21,000 per employee. Maine ranks at the bottom, with $1.50 per employee, the study shows.

From the standpoint of dollars per scientist, Nevada again ranks first, receiving $464,000 per scientist. California is second with $189,000 per scientist. Wyoming is last with $4,000 per scientist.

According to Daddario, when subcontracting is factored in the picture it becomes even more distorted. About 19% of all R&D money was subcontracted out of the state it was awarded in, and another 5.6% subcontracted within the state.

The Connecticut Congressman said that with R&D awards to educational institutions the picture seemed to be more evenly balanced with regard to state lines.



Circle No. 9 on Subscriber Service Card

Soviets reveal helium work . . .

IAF Stresses More Cooperation

by William Beller

WARSAW—Pleas for international cooperation in space so that it can be peacefully exploited for the good of all nations ran like a thread through the week-long technical sessions of the Fifteenth Congress of the International Astronautical Federation.

The Congress, which ended last Saturday, was attended by more than 500 space scientists representing worldwide research institutions and astronautical societies. Reflecting the high interest of the Eastern countries, the Soviet delegation alone included more than 70 members and ranked almost in size with those of the United States and Poland.

The need for international cooperation was evidenced not only in the papers presented on communications, geodetic and meteorological satellites, education and space law, but also in private coversations among the participants.

● **U.S.-Polish cooperation**—The interest of the U.S. in cooperating in the peaceful exploration of space was affirmed by Rep. George Miller (D-Calif.), chairman of the House Committee on Science and Astronautics. He told MISSILES AND ROCKETS in an exclusive interview that "the U.S. would be happy to open up negotiations with Poland on space projects." Miller and Rep. Alphonzo Bell (R-Calif.), member of the Space Committee, attended the IAF Congress "to get first-hand information about the international problems of space exploration and how they will affect U.S. policies and programs."

Miller said one way to work with Poland would be for Polish scientists to prepare experiments for U.S. satellites, and then, if the experiments are accepted, to reduce the data consequent upon them and share it. This is one way the U.S. works with countries such as the United Kingdom, France and Italy.

● **Helium-oxygen**—Soviet scientists revealed some details of their programs aimed at finding out the long-term effects of artificial atmospheres on organisms. In particular, a Soviet paper on the effects of a helium-oxygen atmosphere "indicates the Russians have done a great deal more testing work in this field than we have," W. M. Helvey, head of bioastronautics, Lockheed Missiles and Space Co., observed.

The merit of helium is that during decompression it will not form bubbles in the blood as quickly as nitrogen. This is an obvious advantage for astronauts because of the problem of "bends."

The senior author of the paper, A. G. Kuznetsov of the Soviet Academy of Sciences, described two experiments in which one man spent 10, and another man 25, days in an enclosed cabin holding a helium-oxygen atmosphere at normal barometric pressure.

Both men found that the cabin temperature, though comfortable when they were breathing air, was too cold when they breathed the artificial mixture. The reason for the discomfort was that helium conducts heat faster than nitrogen and thus cools the body.

Specifically, Kuznetsov said the men were normally comfortable at 24°C. In the helium-oxygen atmosphere, the temperature for comfort during the day had to be raised to the region of 24.5° to 27.5°C. At night, the temperature had to be raised a further 1.5°.

There were essential alterations in the Russian subjects' speech, Kuznetsov reported. It was disturbed and the pitch went up 0.7 octave. He concluded, however, that his work indicates man can breathe a helium-oxygen atmosphere without ill effects for upwards of 25 days and possibly for prolonged trips in space.

U.S. researchers have reported that mice survived somewhat longer in a helium-oxygen mixture than in oxygen-nitrogen. It is said that this could have resulted because more oxygen may be stored in tissues saturated with helium than with nitrogen (M/R Aug. 3, p. 32).

This theory was not confirmed by the Russian experiments, an associate of Kuznetsov said.

● **Low-gravity**—Telling M/R of

British-French Missile Deal Confirmed

AN ANGLO-FRENCH agreement has been signed for the development of a new air-launched missile for the British TRS-2 and the French Mirage IV supersonic, strategic aircraft. Primarily an anti-radar weapon, the missile has been designated the *AS-37*.

Range of the missile is expected to be about 28 mi.—determined primarily by the television guidance system to be used. An unspecified guidance scheme could be used to boost this range to 100 miles, an unofficial source told MISSILES AND ROCKETS.

British officials have stressed that the new missile will have a conventional warhead. However, French officials say that an interchangeable nuclear warhead will be optional.

Development costs are placed at $40 million dollars for each country over a period of seven years. Initial operational date for the air-to-surface missile is to be the early 1970's. Hawker Siddeley Dynamics and Engins Matra will develop it.

Considerable confusion erupted over the joint venture when a Labor Party member of Parliament revealed that negotiations were being conducted. A political thrust at the Conservative government, the statement charged that "it is very improper for the government during its last few weeks of life to commit" itself to a $280-million expenditure which is what the labor spokesman claimed would be the development cost. Labor Party officials indicate that the agreement will be an election issue and will receive "careful scrutiny" if they come to power.

● **Missile characteristics**—Basically, the system appears to be an improved version of the *AS-30* air-to-surface missile. Britain has already ordered some of these weapons from Nord Aviation and plans to use them on Canberra bomber squadrons.

The *AS-30* has a range of six miles and carries a 550-lb. conventional warhead. Guidance is provided by the pilot after launch, through a high-frequency radio link with the missile.

some of the Soviet work in low-gravity experiments, P. K. Isakov of the Soviet Academy of Medical Sciences said that reduced g-values are sufficient to obtain normal bodily functions for long periods of time. This conclusion, Isakov said, is based on Soviet experiments by E. M. Jugan of the Academy, in which animals were subjected to 0.28-g and 0.35-g by means of flight experiments.

● **Ranger photos**—The most heavily attended meetings were those at which W. H. Pickering, director of Jet Propulsion Laboratory, showed slides taken by *Ranger VII* of the lunar surface and a film made up from these slides, and Herbert Butler, associate chief for projects, Aeronomy and Meteorology Div., Goddard Space Flight Center, showed the first photographs taken by the General Electric-built *Nimbus*.

The advanced vidicon camera system (AVCS) on *Nimbus* can achieve ground resolutions between ¼ and ½ mi., Butler said. He noted that the system calibrates light intensities. The high-resolution infrared (HRIR) pictures presented by Butler were studied intensely by the participants, particularly by the Soviets.

Butler observed that these pictures are comparable to the medium-resolution pictures taken by RCA's *Tiros*. The HRIR pictures were shot over a narrow band in the 4-micrometer region. This is known as a window in the atmosphere and is not bothered by water vapor, carbon dioxide, ozone or other such variations in the atmosphere. Relatively high concentrations of water, however, such as occur in clouds, close the window.

Butler said the HRIR system gives about a 4-5-mi. resolution of objects on the ground.

The IR sensor is a lead-selenide detector, radiation-cooled to about −74°C.

The high interest of Soviet scientists in radiation work in connection with meteorology was further illustrated by the emphasis they gave the subject in the meteorological satellite sessions.

On the other hand, a United Kingdom paper dealt with ways to determine efficient meteorological satellite orbits. A Polish paper discussed the photogrammetric refraction angle. H. Crane, a General Electric Co. scientist, outlined the role of satellites in oceanography.

● **Buoys and satellites**—Crane suggested using buoys implanted at strategic spots in the ocean to measure current flows, temperature, pressure, humidity, sea state and salinity.

Stored by the buoys, this information would subsequently be gathered by satellites as they passed within range, and later relayed to stations on Earth.

Crane further suggested that the satellite might be able to measure directly some ocean parameters—such as temperature. This idea was questioned, however, in view of the difficulty of correcting for the variations in the atmosphere and its constituents.

Commenting to M/R about the possibility of using a satellite to collect data from Earth, Butler said Goddard is studying the possibility of loading the recording systems of meteorological satellites with synoptic data to superimpose on transmitted meteorological pictures.

"It is one of the many things considered for *Nimbus*," he said.

Butler explained that such synoptic data could include nephanalysis, pressure maps and any other net information, such as latitude and longitude of the pictures, of interest to Earth stations.

● **World system needed**—Tying together the papers on geodetic satellite systems was the expressed need to set up a uniform world geodetic system by means of artificial satellites.

One of the technical problems in determining geodetic positions by means of satellites, however, is the uncertainty of the actual position of the geodetic satellite in space during the time the measurements are made.

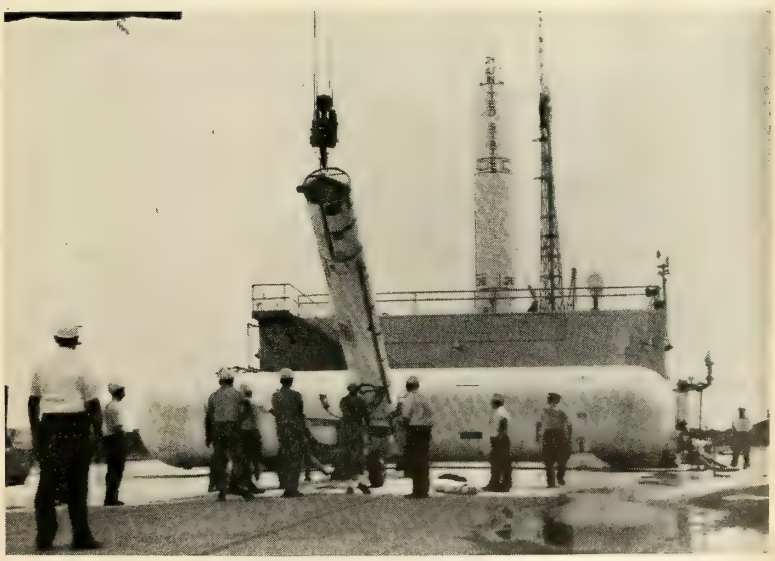
This was brought out by E. S. Keats, project manager of navigation and surveying systems, Westinghouse Electric Corp., who said all present-day systems suffer from this deficiency.

To overcome the problem, Keats suggested the "relative position technique," a new method that "compensates for the uncertainty in satellite position." This is done, according to Keats, by using a reference station along with the station whose geodetic location is to be determined.

"The two stations make intervisible measurements of the Doppler shift of radio signals from a satellite," said Keats. "The reference station must be located at a first-order survey point in an established datum, but it may be widely separated and even at a different elevation from the station whose geodetic position is to be determined."

Measurements of the Doppler shift of the radio signals from the satellite are made at both stations during a common interval of time. Then, by making certain atmospheric corrections and comparing the actual with the calculated position of the reference ground station with respect to the satellite, the coordinates of the unknown station can be found.

Keats said that in one test of the system, "the location of the unknown station was determined to within 1.5 meters of its true value." A contract to make measurements to establish the accuracy of the technique under varying conditions such as distance between stations, satellite path orientation with respect to the stations, and atmospheric changes is now being negotiated between Westinghouse and the U.S. Army Engineers. ■



Preparing for the Worst from Hurricane Dora

DELTA VEHICLE was one of five rockets removed from launch stands at Cape Kennedy last week when Dora aimed toward the area with winds up to 130 mph. Only Saturn SA-7 was left on pad within gantry. However, main storm changed course and apparently little damage was done and little delay caused in NASA's pending schedule.

Experts Say Rise in ComSat Stock Due to Scarcity, Shortsightedness

by Michael Getler

NEW YORK—Communication Satellite Corp. stock, which has more than doubled in price since its initial offering to the public in June, continues its upward movement. But some professionals say it's happening for the wrong reasons.

It is now viewed in some quarters as a very sound long-term investment judged on its own merits. The major reason its price has moved so rapidly to high ground, however, is basically an amazing scarcity of shares for daily trading—in combination with some rather short-sighted short-selling of the issue based in large measure on early, perhaps overly pessimistic, views of its likely performance.

"The instinct of the public, in this case," says George P. Edgar of the security consulting firm of the same name, "has operated better than that of Wall Street. For the most part, professionals have missed ComSat and the public took the ball and ran."

● **Who has bought**—To understand the reasons behind ComSat's very young pricing history it is necessary first to view its extraordinary cross-section of investors.

ComSat has sold 10 million shares, half to the common carriers in the field and half to the public. Concerning those in the hands of the public, Edgar points out that "never in the history of the securities business has there been such a successful, widespread distribution of stock in a corporation's initial financing."

As of July 31, ComSat reported that 130,000 individual stockholders had stock registered in their names, with an average of 27 shares each. This is 70% of the outstanding 5 million shares. In addition, another 50,000 individuals hold ComSat under their broker's, or so-called "street name."

Thus, if this latter group holds even 10 shares each, at least 80% of the outstanding 5 million public shares are represented by the odd-lot (less than 100 share) buyers, who, as Edgar points out, "are generally tenacious, long-term investors."

A large amount of this stock has been bought and put away by the small investor who has a "feeling" about ComSat and what it will buy in the very long term.

The implication of the breakdown of ownership is that the company's supply of stock is extremely limited and its future price will always reflect this.

● **Pain for pros**—Failure of Wall Street to understand the attractive fundamentals of ComSat, and the failure to question the very low-key ComSat prospectus, explains Edgar, prompted many professionals, particularly over-the-counter brokers where the stock was originally sold, to sell the shares short—that is, to sell shares that they did not actually have possession of.

With a strong demand from small investors and greater-than-anticipated activity among some of the institutions (probably also spurred by the attractiveness of ComSat to the small investor) the price of the issue rose, forcing the short-sellers to pay substantially higher covering prices for the issue, which was in short supply to begin with. At least one over-the-counter firm, Edgar reports, has ceased operating as a result of a large loss in handling ComSat.

Edgar—whose business is primarily in advising institutions and who has strongly recommended ComSat—says further buying of ComSat by institutions is another factor which could cramp the supply of "floating" stock, now conservatively estimated to be less than one million of the original five million. At least five major investment funds are believed to have already made commitments in ComSat—they include the Energy Fund, Fidelity Capital, TV Electronics, Ivest Fund of Boston (one of last year's top performers) and the A. W. Jones professional fund.

● **On the floor**—The small investor and institutional interest in ComSat is expected to heighten still further now that the listing has moved to the New York Stock Exchange from its previous over-the-counter status, with which most investors are far less familiar.

With the big-board listing which began last Tuesday, ComSat will also come under greater control than it had over-the-counter. For one thing, all member firms of the NYSE must report their short-selling positions every month. No such requirement exists over-the-counter. For another, the NYSE can suspend trading in the issue temporarily in order to allow sell orders to come in in response to new bids; this keeps down radically fluctuating prices which no one connected with ComSat seems to want.

The job of specialist handling ComSat on the floor of the exchange has been handed to the Broad Street firm of Picoli, Caulfield and Co. Part of the specialist's job is to insure a smooth matching of buy and sell orders. However, some observers point out that again the scarcity of ComSat stock may make it difficult for specialists, who sometimes have to sell short in order to meet demand.

● **Coming stimuli**—While more hard facts on ComSat are still awaited, there are three events in the near future which will again focus interest on it and may cause a price stir.

One is the firm's first stockholders' meeting, slated for Washington on Thursday. Another is the expected attempt to televise the Olympics from Japan via the Hughes *Syncom III* satellite, which while not designed for TV, is generally associated with ComSat's coming *Early Bird* satellite.

The third significant date will come early in December, six months and one day after the initial ComSat issue. On that date holders of the stock since its issuance can sell and pay only a capital gains tax rather than the higher tax structure which accompanies shorter-term holdings.

● **Growing backing**—The number of individuals and firms who are overtly bullish about ComSat is still small, but increasing.

For example, Shields and Co., in an optimistic report issued in July, became the first prominent member firm (and remains the only one) to deliver a strong recommendation for ComSat to its clients.

The things that Shields, Edgar Associates and some other supporters are saying about ComSat's real value amount to this:

ComSat is far less speculative than its original billing. In fact, Edgar calls it "the bluest of the blue chips"—with blue-chip customers and management from blue-chip companies, the prestige of the U.S. firmly committed to its success, and the benefits of a dynamic technology (not to mention several hundred million dollars in free R&D absorbed by DOD and NASA in the development of these satellites).

The ComSat prospectus, which had to be conservative in order to protect the small, unsophisticated investor, was actually misleading, according to Edgar, because it overstated the risks and understated the company's attractive fundamentals. Most professionals, says Edgar, went no further than the prospectus, while there were volumes of Congressional testimony available which did indeed point to the attractive basics.

In support of his argument, Edgar says the prospectus did not indicate that substantial agreement had been reached on the international consortium, which was signed seven weeks after initial issue (M/R, Aug. 3, p. 14). The extension of ComSat to a virtual worldwide charter was a key question for many investors. Edgar argues that these things don't happen overnight and that some indication of the likelihood of agreement should have been given.

As an offshoot of this development, ComSat was underwritten by an additional $78 million in foreign investment, which has put the corporation in what Edgar considers to be a very favorable cash position.

The prospectus also failed, Edgar says, to acknowledge the existence of a large number of engineering reports which pointed to a much earlier profitable picture (before 1968) than most observers believed possible. Also, the high probability of launch vehicle success was not indicated strongly, he told M/R. The Shields report also states that the problems of unsuccessful launching have been overemphasized.

● **Glamor/growth seen**—Regarding the profit picture, the Shields report says ComSat could be generating revenue at a significant rate by late 1965 through its *Early Bird* system. However, it adds, significant profits are unlikely before the installation of the second-generation system in 1966. Shields also estimates that ComSat will earn a rate of return on its investment of close to 10%, that its per-share earning could range to $5, and that the investment capital base will be an expanding one for some time.

Though not in the short-term situation, Shields reports, "as a long-term holding, ComSat common seems to offer the promise of substantial capital appreciation."

Edgar, seeing ComSat with an exclusive global franchise, believes the stock will sell at least 50 times earnings by 1970, earning between $3-5 per share with a price range of $150-250 per share. (Current glamor/growth stocks sell between 30-50 times earnings). Edgar sees the favorable cash position allowing ComSat to pay out a large part of its earnings in currency, something which has considerable appear to the growing list of foreign investors.

Edgar Associates and Shields both note the prospect for early revenues even with the *Early Bird* system. Edgar says revenues from *EB-I* could be in the neighborhood of $35 million by early 1966. AT&T has already said it will lease 100 channels; observers believe the government will lease several for administrative communications.

In addition, other common carriers are viewed as certain to lease channels. Shields estimates that ComSat revenues from the two-satellite, 480-channel *Early Bird* system will approach $100 million if fully utilized.

● **Overly economical?**—The economies of communication satellite operation in comparison to cables "are almost frightening," says Edgar, who cites this as a major item which has also escaped many professionals.

The cost per voice-channel-mile via a ComSat has been estimated at between $25-50. The figure relating to TASI-assisted submarine cable are three times greater, according to informed sources.

In fact, Edgar notes, regulation of ComSat, which is still not completely established, will be employed more to establish a *floor* under its rates rather than a ceiling on them. This will be necessary, he says, to protect the high investment in submarine cables. ■

Unique Lava Tests Show Need for Apollo Suit Changes

TESTS in the lava fields of Oregon have revealed the need for three improvements in the *Apollo* spacesuit, while reassuring engineers on its overall technical feasibility.

NASA officials said following the tests that:

—Hip joints of the suit must give greater mobility to allow astronauts to step over or onto rocks and higher ground.

—Ventilation flow to the head area must be increased to speed the astronaut's personal heat removal and prevent fogging the visor.

—The helmet must provide better downward visibility, particularly for rough terrain, because the prototype Hamilton-Standard suits keep the astronaut looking two or three steps ahead.

These were the conclusions of Earl La Fevers, test director for the Manned Spacecraft Center's Crew Systems Division. The suit was tested by MSC engineers and astronaut Walter Cunningham over beds of pumice, basalt and obsidian lava near Bend, Ore.

● **Easy Going**—Mobility on level ground was better than expected, La Fevers said. The men were able to walk at about 2.6 mph under pressurization. (Normal walking permits travel at about 4 or 5 mph.)

Climbing slopes as great as 30 degrees will not prove too difficult. Engineers climbed one 30-degree slope over 40 ft. of rocks and boulders in 12 minutes.

Astronauts descending into craters probably will carry a rope with them and attach it to rocks at the rim of the crater, La Fevers speculated. They would use the rope to climb back up to the rim, he said, because of the relative ease in climbing up with the rope. In the tests climbing time on the 30-degree slope dropped from 12 minutes to 3 minutes when the man could hold onto the rope and pull himself forward.

● **Outer suit**—Some design changes are due also for the bulky "thermal overgarment" designed to insulate astronauts from the Sun's heat and to slow down micrometeorites. The thermal garment worked well, but when zipped up around the man's head, it leaves only a slit for the eyes, reducing visibility. Mittens for the garment proved too bulky for any work requiring manual dexterity, La Fevers said, and the material was too slick for gripping small objects.

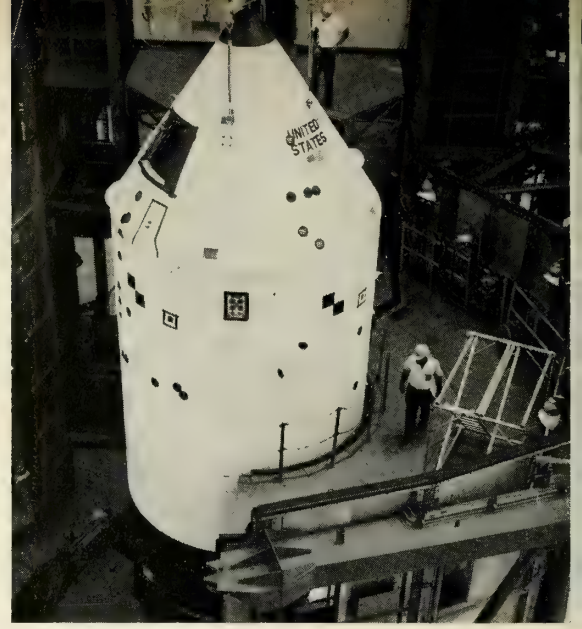
The 40-lb. back pack carrying the portable life support system should be contoured more closely to the astronaut's back, La Fevers said.

Climbing the rocky slopes proved easier than anticipated. Falls and slips were few, he said, and in most instances, the man fell to his knees and rose without difficulty. Astronaut Cunningham was the only man to fall completely and roll down the slope.

A device officially dubbed the "lunawalker" proved the astronaut's best friend for traversing moderately rocky ground and crossing crevasses. Designed by Jack Eggleston, head of the Space Environment Division, the walker resembles those used by babies, cripples or the elderly. Made of aluminum tubing, the walker consists of four legs attached to a wrap-around frame. It weighs less than 10 lbs. ■

Some changes made . . .

SA-7 Carrying Apollo Boilerplate



APOLLO Command Module boilerplate being mated to Saturn SA-7 booster at Complex 37, Cape Kennedy.

THE SPACE AGENCY this week will attempt to launch its seventh *Saturn I* booster on an R&D flight test which will place a boilerplate *Apollo* Command and Service module in low-Earth orbit.

The flight is scheduled for no earlier than Sept. 17. If successful, it will put its 36,700-lb. payload into an orbit with a perigee of 115 statute mi. and apogee of 135 statute mi.

All six previous launches in the R&D program have been successful. Following *SA-7*, three other *Saturn I* vehicles will be used to launch a large meteoroid detection satellite called *Pegasus*.

Although similar to the flight plan for *SA-6*, the seventh *Saturn* vehicle will have several minor changes, including the first full-time control of the vehicle by the ST-24 guidance system platform.

Other changes include:

- The first-stage cut-off system has been improved so that less propellant will be left in the tanks. The lighter weight should increase vehicle performance. The cut-off system utilizes liquid-level sensors in the four outer tanks. When the propellant level lowers to any one of these sensors, the cut-off sequence is initiated by the guidance computer.

On *SA-7*, the four liquid-level sensors have been placed lower, allowing more complete propellant consumption. About 8,500 lbs. of propellant is expected to remain in the tanks and propellant lines at cut-off, compared with about 14,000 lbs. on *SA-6*.

- Changes have been made to the S-IV second stage's propellant venting system in order to reduce the payload's spin and tumble rate in orbit in preparation for the later flights of the *Pegasus* satellites on *Saturns 8, 9* and *10*.

Previously, liquid hydrogen and liquid oxygen residuals have vaporized during orbit and escaped through a single vent in each system. In the vacuum of space, this venting has had a minor propulsive effect which induced roll rates detrimental to the large-wingspan meteoroid satellites.

Non-propulsive venting systems have now been devised. LOX and liquid hydrogen will each have two vents, located 180 degrees apart.

- The eight H-1 engines in the booster use for the first time an improved gear box, known as the Mark III H, and improved LOX domes. ■

New Apollo Contracts Total More Than $566 Million

THREE NEW Project *Apollo* contracting actions totaling $566.4 million have been announced by NASA and the Navy Dept., with the bulk going to North American Aviation, Inc.'s Space & Information Systems Div. for a $496-million nine-month extension of its work as prime contractor for the three-man spacecraft.

Another contract—valued at $64.9 million—was awarded by the Bureau of Ships to General Dynamics/Electronics, Rochester, N.Y., for the conversion of three World War II tankers into Project *Apollo* tracking ships.

Sperry Rand also received $5.5 million for installation of navigation systems on the ships.

The NAA extension brings the total value of its contract to $1.436 billion, more than three times the NASA estimate when the work was announced in December, 1961.

The extension calls for five additional flight *Apollo* Command and Service modules, one additional flight boilerplate spacecraft and one more full-scale mockup to be built at the Downey, Calif., plant. It also includes the building at NAA's Tulsa, Okla., plant of nine adapters to house the *Apollo* Lunar Excursion Modules aboard the *Saturn V* booster.

The contract now runs through Feb. 15, 1966. It will provide the Manned Spacecraft Center with 14 spacecraft, 16 boilerplate spacecraft, 10 full-scale mockups, five engineering simulators and two mission simulators.

It also provides for test fixtures, test operations, monitoring and analyzing flight and test information, and other engineering and management tasks necessary for manufacturing and checkout operations.

Much of the GD/E work will involve the installation of electronic tracking gear on board the ships. The tracking equipment is being procured by the space agency's Goddard Space Flight Center.

The firm will also cut the ships in half and add a new mid-body to make room for the tracking gear. Work will be done at the General Dynamics/Electric Boat, Fore River Shipyards, Quincy, Mass.

Martin Gets Award for Further Work On Random Access Discrete Address

Division reported also working on similar system for Air Force; DOD decision on operational use awaits evaluation at Huachuca

by Charles D. LaFond

ORLANDO, FLA.—RADA, a Random Access Discrete Address tactical communications system, will undergo further development for the Army by Martin Company's Orlando Division.

Under a $40,000 contract recently announced by the U.S. Army Electronics Laboratories, Fort Monmouth, N.J., Martin will continue its R&D program started in March, 1963, and refine its design for the portable/mobile field radio telephone system. In the earlier program, Martin, Radio Corp. of America and Motorola, Inc., were each given 2-million contracts by the Army to perform feasibility studies and produce a basic hardware design for a highly advanced field communications system.

Following the 12-month contracts, Martin was ultimately selected to continue with RADA for possible future use throughout the Army. Reportedly, the division is developing a similar system for possible use by the Air Force as an emergency air-to-ground communications system.

A decision to develop the system for operational use apparently has not yet been made by the Dept. of Defense. This will probably depend upon completion of the current contract and test and evaluation of the system by the Army at its Fort Huachuca, Ariz., Electronics Proving Ground late next year.

● **Army requirements**—RADA was developed to meet Army requirements for a secure, reliable and relatively easy-to-operate field communications system for use within a deployed infantry division. The area of coverage is roughly a rectangle 48 x 125 kilometers.

Individual radio transmitter design requirements called for a peak power of 20 watts, operation in the 300-400-mc frequency band and a nominal line-of-sight operating range of 10 km.

The system had to be capable of handling 3,400 subscribers per division, 80 simultaneous transmissions and provide means for voice, data, teleprinter, and slow-scan video operation.



HANDSET, developed by Martin Co.'s Orlando Div. for use with RADA field communications system, is provided with complete push-button dialing. Lower section includes buttons for general alert, command override, normal call and conference call.

● **Martin RADA system**—Martin's prototype employs an automated, computer-controlled dial system. The computer logic permits automatic sequential search for intermediate radio relay to the addressee.

The hand set used for voice transmission and reception is provided with a complete push-button dial for address numbers and for command override, general alert and conference calls.

Twelve channels are reserved for artillery-support communications.

In operation, the system produces a busy signal if the address is already in operation, thus preventing accidental or intentional eavesdropping by friend or foe. During a command override, the addressee is notified visually and audibly of the impending call and is given 10 seconds to complete his current conversation before override occurs.

Crosstalk is avoided normally by the computer selection of circuits from 6 to 8 channels apart. System design, said Martin, also avoids multipath and backscatter signal degradation.

In addition to the basic subscriber field radio set, the RADA system would employ widely dispersed retransmission units. When two communicators are within radio range of their individual sets, conversation is direct. When beyond normal range or if RF interference jams the signals, the automatic sequential search routing technique comes into play. A search is made by the system for the best transmission path using the best available frequency to assure high transmission fidelity.

Also, if during a transmission contact is lost because of terrain interference or distance, the caller need only re-dial his addressee and the system will introduce a new channel or path to reconnect the circuit.

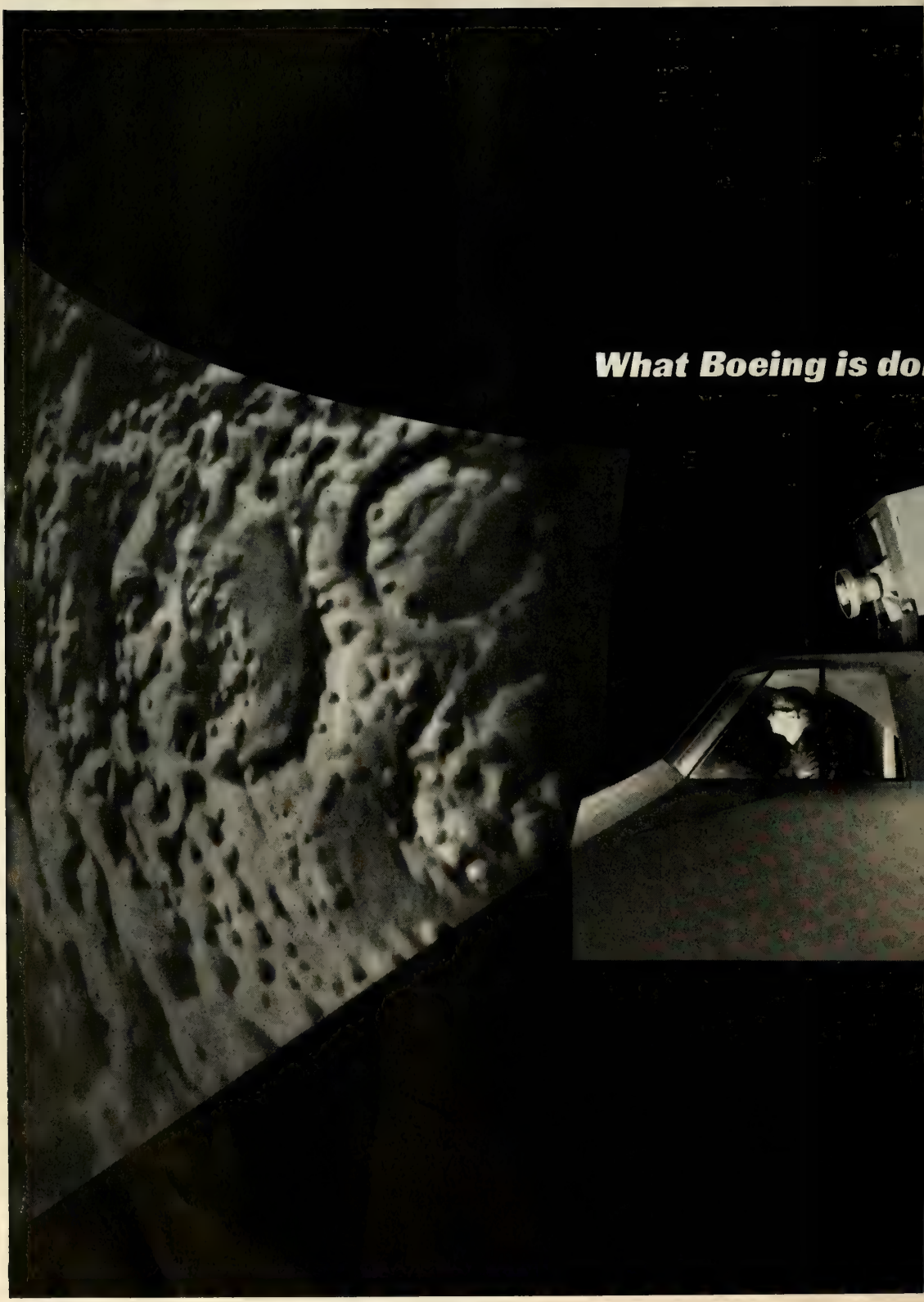
● **Operational designs**—The system now under design by Martin will provide a portable or mobile set for voice use weighing less than 35 lbs. It will be self-contained and carry a battery.

Electronics will employ integrated circuits and modular construction for ease in field repair. Cost of the individual sets, said a Martin official, will be about equal to that of an AN/VRC-12 field radio set.

For other transmission modes, adapters and other equipment will be added to the basic radio set.

Operator training is expected to be minimal. Operation of the set can be learned easily with an hour of field use, and second echelon maintenance can be taught within an equally short time. Module replacement will probably be handled by third or fourth echelon maintenance personnel. ■

Theory, study, practice...



ts SPACE RESEARCH LABORATORIES:

Space Simulation

Using projected television pictures of the moon's surface and manual controls that operate through a computer, aerospace pilots simulate lunar landings and takeoffs, and re-entry into the earth's atmosphere. This advanced Boeing simulator (shown at left) has already been used in the astronaut training program.



Microelectronics

To develop microminiature circuitry for missiles and space vehicles, Boeing people are working with circuits so thin a thousand hardly equal the thickness of a safety razor blade. Microelectronics research, and other space-oriented programs, will be housed in Boeing's new Kent research center.

Space Environment

Boeing's space environment laboratory will house 11 vacuum chambers that duplicate the extreme cold of outer space, solar radiation and vacuums equivalent to those found 600 miles above the earth. One of these advanced chambers will be big enough to test future manned spacecraft.

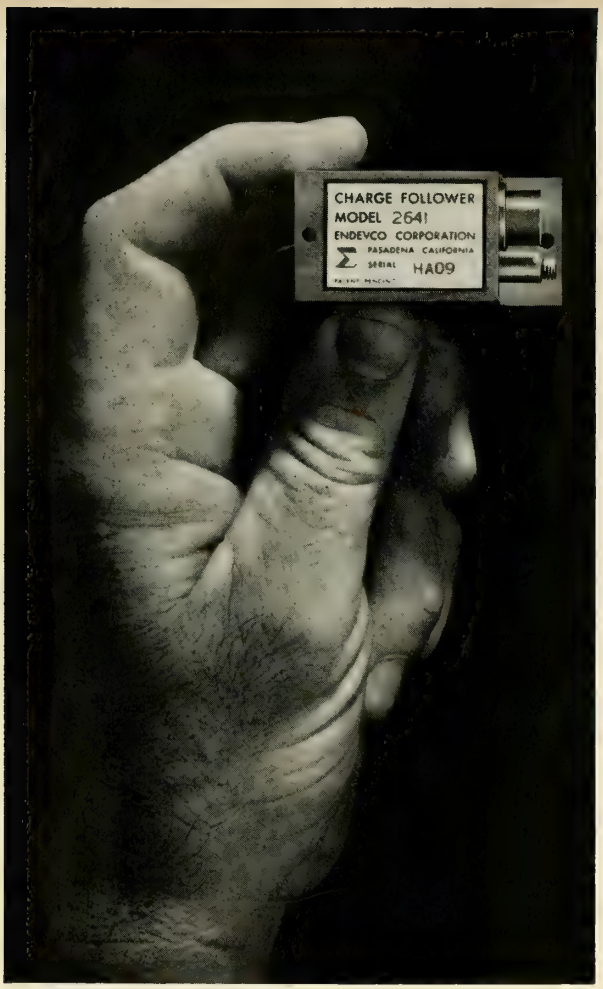


Exotic Metals

The materials and processes laboratory is continuing Boeing studies of lubricants, ablatives and super alloys for use in outer space. Typical of Boeing advances in this field is pioneering research in the adaption of such exotic metals as molybdenum and columbium for utilization in space vehicles.

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Crackdown on Employee Welfare Programs Sought

Committee cites vague wording of ASPR's allowing losses to be passed on to Government; ten leading contractors scrutinized; DOD has taken some action

by Heather M. David

A CONGRESSIONAL investigating subcommittee has asked the Dept. of Defense to change its contracting policy and Armed Services Procurement Regulations (ASPR) provisions regarding contractors' employee health and recreation expenses.

The House Armed Services Special Investigating Subcommittee headed by Rep. Porter Hardy, Jr. (D-Va.) called for the setting of penalties aimed at discouraging defense contractors from including in overhead or elsewhere items which come within categories which are not allowable as items of cost.

These specific recommendations were also made:

—Insure that Government auditors review the operations of employee welfare organizations to establish that the funds turned over to such organizations do not exceed the amounts needed to defray the costs of reasonable and worthwhile activities.

—Require defense contractors to finance employee welfare organization programs out of pocket, and apply vending machine receipts in their entirety as an offset on a *pro rata* basis to related allowable costs of contracts.

—Apply all food service profits to all food service losses.

—Establish coordination, education and training programs to resolve divergent views of resident auditors and contract negotiators on allowability of charges.

—Initiate rotation policies for negotiators and resident auditors limiting the tour of duty at one location.

—Prohibit reimbursement of contractors for food services losses when the service is intentionally operated on a less-than-breakeven basis.

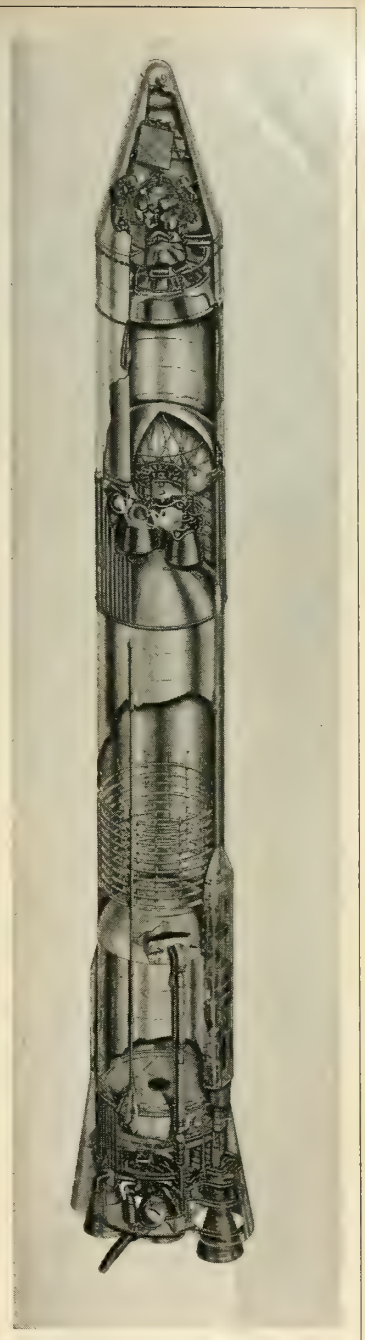
—Require defense contractors to maintain accounts in such a fashion as to make available to Government auditors full disclosure of all morale and recreation expenses.

Some steps already have been taken by DOD. In a letter to the committee, Deputy Assistant Secretary of Defense (procurement) Graeme C. Bannerman said that instructions have been issued for increased staff training.

DOD has also initiated action to see that income from vending machines and similar activities should be treated as a credit to the overhead accounts of the contracts for contract cost allowance purposes. In addition, the Department has started action to provide ASPR language which would disallow planned losses on food services activities as contract costs.

● **Lack of consistency**—The committee said that among the 28 contractors (at 36 locations) examined, the employee morale and recreation activities were so diverse that no pattern was apparent. Some of the $6 million worth of activities charged by these contractors in the 12-month period were directly financed, while others were indirectly financd—for example, by contribution of vending machine profits to the employee welfare organization.

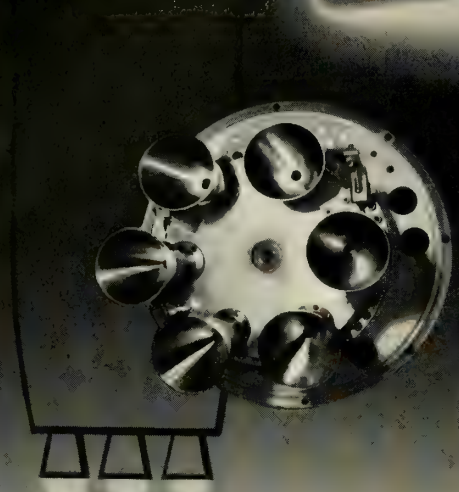
The report stated that losses in food services were charged to the Government, except in a few cases, while profits from vending machines were turned over to the employee organizations. In



Details of Atlas/Centaur/ Surveyor in Combination

FIRST RELEASED drawing of Atlas/Centaur/Surveyor combination, from General Dynamics/Astronautics, maker of both the Atlas booster and Centaur high-energy liquid-fueled upper-stage vhicle. Surveyor spacecraft is in protective nose fairing atop the Centaur.

The Nose Gets Hot



But So Does The Other End

The front-end heat transfer problems of hypersonic flight — nose cone configurations, spacecraft designs, ablative cooling methods — are studied in many laboratories. Aside from extensive programs in these well-publicized areas, however, Cornell Aeronautical Laboratory plays a leading role in solving the equally important but less understood problem at the other end of the missile: the destructive heating of the missile base.

The possible result of radiation, external burning of fuel-rich mixtures, and interaction and reverse flow of exhaust gases, base heating of rocket vehicles at high altitudes has been recognized as one of the major causes of mission failures.

Extensive Cornell Aeronautical Laboratory experience in shock tube technology has been adapted to this problem, with particular emphasis on the NASA/Marshall Space Flight Center Saturn program. CAL's researchers duplicate rocket motor operations at model scale through a pressure altitude ranging from sea level to 350,000 feet. Variations of base heating with Reynolds number have been investigated and base recovery temperatures determined. Resulting data have been highly significant in the design and subsequent successful flight testing of Saturn stages.

This applied hypersonics project is only one of the areas of research in which CAL's technical staff is leading the way.

Others include computer sciences, applied physics, electronics, operations research, aerodynamic research, flight research, applied mechanics, vehicle dynamics, life sciences, and systems research. If your experience qualifies you to join this team, we invite you to mail in the coupon below. It will bring you an interesting briefing on this community of science.

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addition, some of the losses incurred were from executive dining room gourmet dinners and lunches.

Some of the food service operations were deliberately conducted on a loss basis, "with assurance that the Government would absorb the loss," the committee charged.

● **ASPR's at fault**—Basis of the difficulty, the subcommittee indicated, is that ASPR section XV relating to overhead is worded so vaguely. ASPR 15-205.14, the committee noted, says that food services "include operating or furnishing facilities for cafeterias, dining rooms, canteens, lunch wagons, vending machines . . . and similar services . . ." Further, the committee said, the ASPR says that reasonable food service losses are allowable, but profits shall be treated as a credit except when irrevocably set over to an employee welfare organization.

What happens, the committee indicated, is that "gross losses are passed on to the Government while the gross profits are usually turned over to employee organizations." At one company, coffee service losses of $18,000 over a three-month period were charged off to the government, while a subsequent profit of $6,000 when the company converted to vending machine coffee was given to the employee association.

ASPR (15-205.10 and 15-205.11) language also permits contractors to charge off costs of cocktail parties or other parties which would be unallowable if for purposes of amusement, diversion or social activity. However, if billed as employee welfare they can be charged. "Meals specifically unallowable . . . cease to become meals and are allowable when they are served at recreation activities. A cocktail party is no longer entertainment when its purpose is employee morale," the report stated.

Of the $6 million in question, the Hardy subcommittee said, about $3.5 million was spent for athletic and club activities, $1.5 million for cafeteria losses, $434,000 for Christmas gift turkeys, $386,000 for parties and entertainment, and $162,000 for outings.

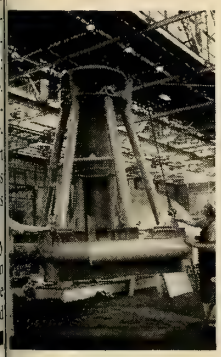
Companies which came under scrutiny by the General Accounting Office at the request of the subcommittee were: Aerojet-General's Azusa and Sacramento plants; Hughes Aircraft's Culver City and El Segundo locations; North American Aviation; Martin Co. Denver; Raytheon Co.; Pratt & Whitney Aircraft Division of United Aircraft Corp.; General Dynamics/Fort Worth; International Business Machines Corp.; Aerospace Corp., and Douglas Aircraft Co., Inc.

Witnesses during the hearings July 21-23 were government auditors from the Dept. of Defense who allowed the costs. No industry witnesses were called upon for formal testimony. ■

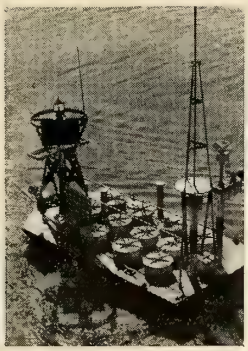




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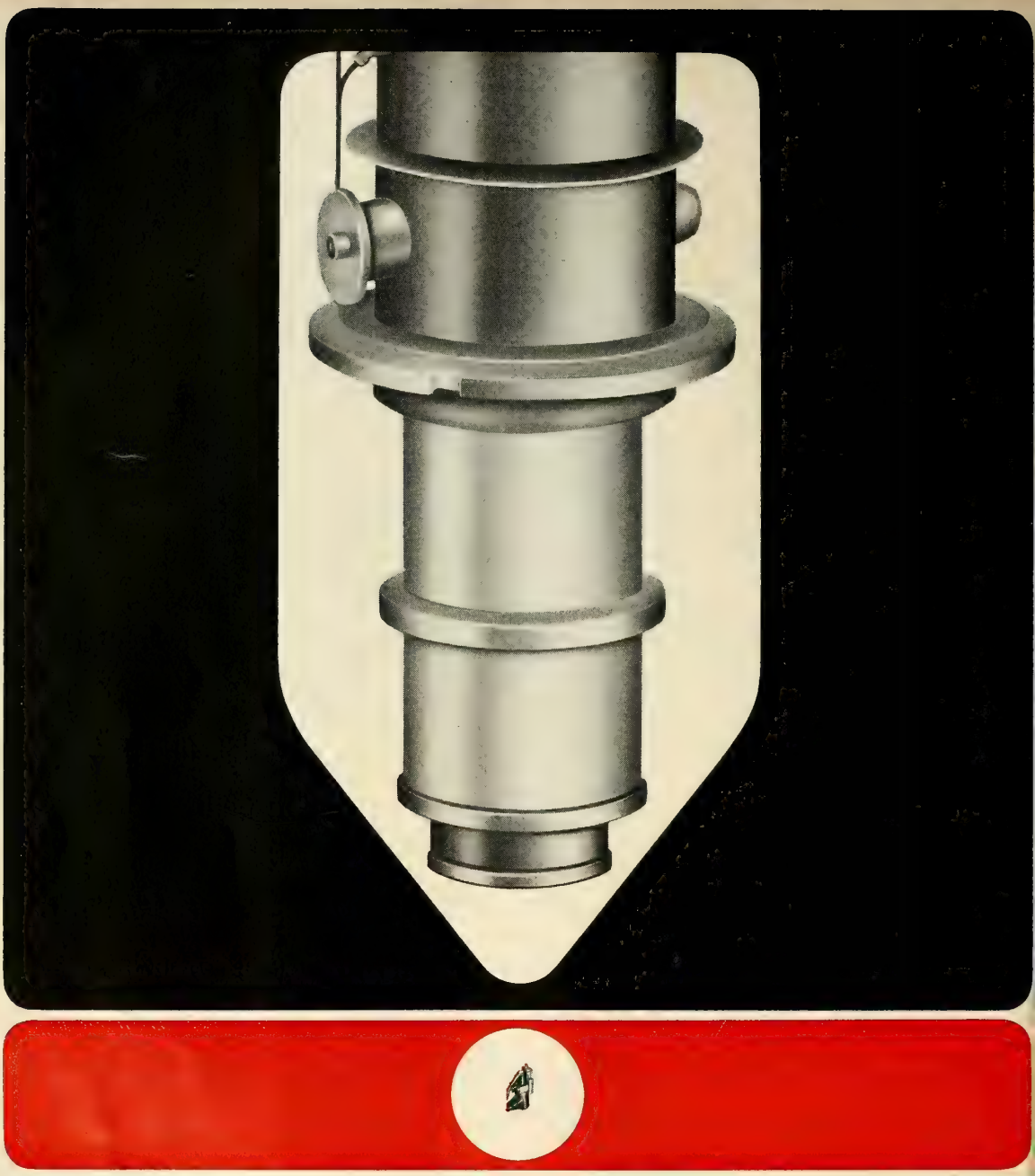




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Technical Countdown

MATERIALS

Submicron Thoria Dispersion Achieved

Homogenous dispersion of submicron thoria (50 to 500 Angstrom particle size) in a tungsten matrix has been achieved at Vitro Laboratories, a division of Vitro Corp. of America. Arthur S. Locke, director of the labs, says an independent source verified the dispersion through analysis of the material using electromicrograph techniques and X-ray diffraction methods. Experimental quantities of thoriated tungsten are available in sizes up to 50 lbs. Preliminary studies indicate this method of dispersion preparation is applicable to other metal alloy systems.

Acoustical Method Used for Cryogenic Readings

A method based on the speed of sound in helium gas using the principles of the ultrasonic interferometer will serve to establish a provisional temperature scale from 4° to 20°K. One objective of the program at the National Bureau of Standards' Institute for Basic Standards is to achieve a primary temperature scale including the range from 4° to 14°K. Since the acoustical thermometer is not convenient for routine temperature measurements, germanium resistors are used as secondary thermometers. A group of these resistance thermometers calibrated against the acoustical thermometer will maintain the provisional scale.

Radiation Induces Planar Surface Effects

Irradiation of silicon planar devices with cobalt 60 gamma rays reveals that such devices show effects similar to gas encapsulated mesa devices, claim engineers in the Missile and Space Div. of General Electric. Although junction passivation with inorganic materials minimized the effects, present manufacturing techniques and controls are often inadequate, they report. Chief problem in passivation and control of surface properties appears at the base-emitter region.

PROPULSION

Thrust Test Device Under Contract

An integrating microthrust balance will be delivered to NASA's Manned Spacecraft Center, Houston, for use in evaluating *Apollo* control rockets. Developed by Rocket Research Corp. under an earlier contract from the Goddard Spaceflight Center, the instrument measures impulse directly and is capable of precision determination of the performance of a 1-lb.-thrust rocket during a pulse of 0.01 second duration. Thrust measuring ability extends up to 100 lbs.

ELECTRONICS

Cost-saving by Data Compression

Use of data compression techniques can reduce costs in a typical flight data reduction center by $16,000 per week, according to engineers at Lockheed Missiles and Space Company. They envisage a system that will process either FM/FM or PCM telemetry using a zero-order predictor algorithm. This predicts that following samples will be within the specified tolerance of the first sample and, if so, considers the information redundant and not to be transmitted. First sample not to meet this prediction is transmitted and becomes the new reference for predictions. The Vandenberg Automatic Data Evaluation equipment uses a hardware comparator of this type, with software control.

S-band Receiver Tuned Electrically

A technique of electrically tuning microwave receivers that promises to be suitable for the 0.5 to 100-gc range has been developed at Watkins-Johnson Company. Components for the 1 to 18-gc range have been completed and a receiver will be constructed by the firm in the near future. Key feature is use of two electrically tunable yttrium-iron-garnet preselectors with a TWT pre-amplifier. An S-band front-end tunes linearly with a control signal of −2 to + 2 volts.

Avalanche Transistors Use Surface Control

By controlling avalanche breakdown voltage in transistors with an external field, Clevite Semiconductors has obtained devices that promise operation in the 10-gc range. Structures for this frequency, Clevite said, would have dimensions of about 10^{-4} cm. External field is applied through surface insulating layers.

Octave-Bandwidth TWT Produces 100-w CW

Helix-type traveling wave tubes that provide 100 watts of CW power over octave bandwidths at X through S-band wavelengths have been developed by Sylvania Electronic Products. Key to attainment of this power is the supporting of the helix by three ceramic rods of high thermal conductivity.

Lunar X-ray Diffractometer Developed

An 18-lb. X-ray diffractometer has been designed by Philips Electronics for use in *Surveyor* spacecraft to analyze structure and composition of such materials as silicates, sulphides and glasses in lunar rocks. It consists of a scanning goniometer with a Cuka source, proportional detector and inverted curved sample-holder with beryllium-foil window. The instrument occupies 0.9 cu. ft. and requires 70 watts of power.

Apollo Radiation Detectors Ordered

An onboard radiation detector for the *Apollo* lunar-mission spacecraft will be developed for NASA by EON Corporation and Quadri-Science, Inc. Bracket-mounted during flight, the device also will be designed to be hand-carried by astronauts exploring the lunar surface on foot. The recently announced $75,000 contract calls for delivery of six instruments within 12 months. The meter will have a measurement range from 0 to 100 rads/hr. and will operate throughout a temperature range of −250° to +200°F.

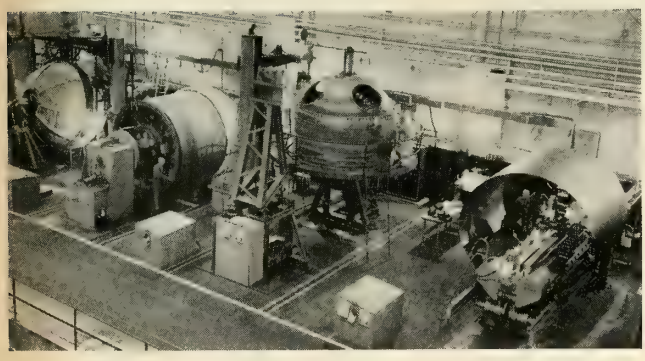
Ultrahigh Vacuum Calibration Extended

A new system capable of absolute pressure calibration up to 10^{-10} torr will be developed by National Research Corp. under a $77,000 contract from the George C. Marshall Space Flight Center. Accurate gauge calibration is now limited to the 10^{-9} torr range—comparable to a 400-mi. altitude. Major applications of the new system, designed by the Norton Co. subsidiary, will be in space simulation, satellites and pure research.

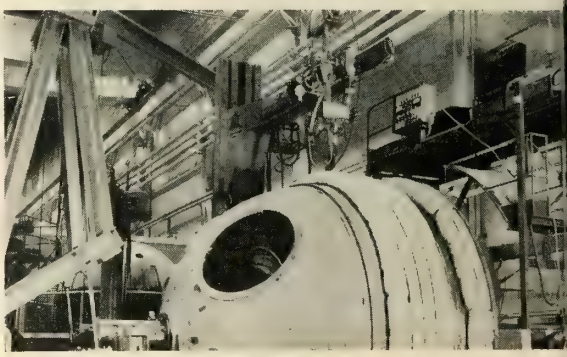
Westinghouse Know-How Speeds Flow Of 120-in. Cases for Titan III-C's

New Rocket Motor Case Dept. applies firm's generator production experience to solve fabrication headaches; welds 90%+ defect-free

by John F. Judge



VIEW OF loaded welding fixtures along main welding aisle.



WELDING of female clevis joint to forward closure barrel.

LESTER, PA.—With all major fabrication and tooling problems solved, the Rocket Motor Case Dept. of Westinghouse Electric Corp. is now producing 120-in.-dia. solid rocket motor cases almost as a matter of routine.

The first twenty months of the department's existence covered the development of an alternate center-segment case fabrication method and the elimination of a peculiar welding problem.

The firm brought its experience in steam and nuclear reactor power generator fabrication to the business of supplying solid rocket motor cases and landed part of the joint case effort for United Technology Center's 120-in. *Titan III-C* solid strap-on boosters.

Curtiss-Wright Corp. is the other contractor on the program.

The Westinghouse work is located at the firm's manufacturing plant near Philadelphia, Pa. The facility fabricates huge steam generators for electric power plants and was already equipped with the massive tooling and fixturing required for the 120-in. case program.

The case material is Ladish D6AC, a low-alloy, high-strength steel originally developed for hot work die applications, but subsequently used in various solid rocket weapons systems as motor case material.

Ladish D6AC is electric furnace air-melted and then refined by remelting in the vacuum consumable electrode process.

A great deal of welding and other metal processing data has been built up around earlier missile programs such as the Air Force *Minuteman* ICBM, but the 120-in. case is a departure in that both metal thickness and segment sizes are much greater.

The extreme inspection carried out with the raw plate effectively prevents the introduction of failure-producing flaws into the finished product—but this is only with the parent material. Thus the joining process assumes critical importance.

● **Shop floor management**—The key to the production of reliable rocket motor cases is unflagging attention to the mundane details of metal working and welding coupled to an extensive quality assurance procedure.

There are still flaws—some repairable within the original specifications and others demanding total rejection. However, the intensive quality control methods at Westinghouse linked to a swiftly rising learning curve have resulted in over 90% of the current welds being defect-free.

Charles M. Miller, manager of the Rocket Case Dept., says all welds are subjected to a minute inspection for defects and all defects are found. There are carefully specified flaw size requirements and these are extremely tight on the 120-in. program even though tests

have shown that some defects in the thick-walled pressure vessels would have no effect on end performance.

Yet the very same flaws would be disastrous in a thinner-walled vessel. It is a question of reliable performance, and in a development program as cost-conscious as the *Titan III,* extremely conservative design is used. Thus the flaw requirements are stringent.

● **Premium method developed**—At one point in the case program, an alternate rolled ring forging route to case segments was investigated to eliminate the necessity of a weld. The weld problem was solved, but the back-up approach resulted in the elimination of a longitudinal weld in a 120-in. case segment.

Developed by the Ladish Co. with the assistance of both Westinghouse and United Technology Center, the process proves to be more expensive, but offers discernible weight savings. The rolled ring forging approach provides a product as good as the best resulting from the roll-and-weld method used in the current Westinghouse program.

dome fabricator were cautioned against using permanent or electro-magnetic handling devices.

These steps, combined with advanced demagnetization techniques, alleviated the problem.

● **Manufacturing process**—The center segments are rolled and welded. Ultrasonically inspected for flaws at the mill, the plate—32 ft. long and 9 ft. wide—is crimped at each end and then rolled into a cylinder.

Prior to the crimping operation, end. The rolled cylinder is then placed in the longitudinal seam welder and clamped against a weld backup plate at high pressure by a number of individual fingers.

The butt ends are carefully matched and clamped firmly in position for the welding operation. Westinghouse welds from one side in a series of filler passes over the joint with a tungsten-inert-gas welding head.

All longitudinal welds are made from the inside, while curved or girth welds are performed on the outer diam-

with respect to the inside with the aid of a tracer mechanism.

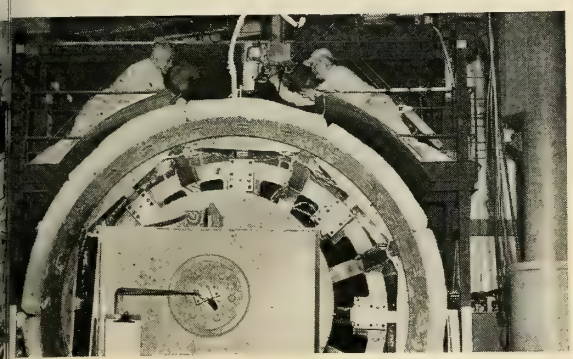
The next operation is a proprietary sizing step—made necessary by the match requirements of the thrust termination port rings that must be welded to the dome.

The Westinghouse creep dome sizer uses an inner heater, a stainless steel hemispherical mandrel, a dome clamping mechanism and an outer heater.

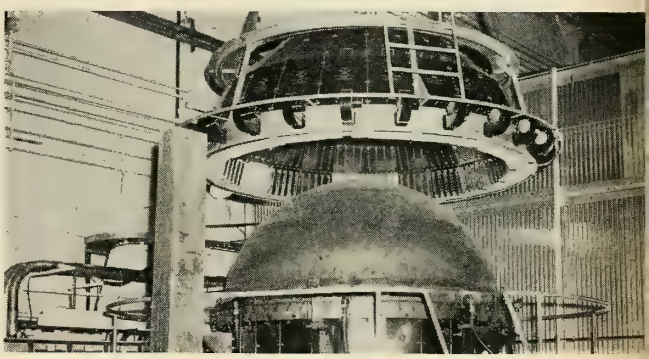
When dome is installed and brought to temperature—about 1250°F—the inner stainless hemisphere expands at a greater rate than the D6AC steel dome. The sizing action then takes place in the dome through creep of the material.

● **Dome welding**—Westinghouse designed a special welding fixture for the dome sections. The fixture is mounted on a horizontal boring mill with its axis at 45 degrees to the fixture. The fixture axis is rotated horizontally and a port opening trepanned in the dome. The weld preparation area is machined.

The fixture is then rotated 45 de-



CLEVIS RING joint being welded to center segment.



DOME CREEP sizer with outer heater being removed.

"If someone wants a weight reduction in such boosters," says Miller, "we have the process."

Another unique problem with the 120-in. case stemmed from residual magnetism in the dome segments. A monolithic dome has no detectable magnetic field, but the D6AC material is an excellent permanent magnet. Once a hole is trepanned in the dome, a surprising welding problem is created.

The high temperature inert gas welding process depends on the conducting gas to strike and hold the arc. Magnetism in the dome affects the welding arc as it moves around the hole in attaching the ring sections. The arc blow resulting from the residual magnetism proved a major problem.

Westinghouse eliminated Magnaflux inspection operations on the dome prior to the welding and relied on other procedures. Even the plate vendor and

eter. The method of welding from one side does not require a backup gas.

In such welding, a proper thermal history is of prime importance. Each weld area is brought to 650°F in a preheat step and held at this temperature during the welding operation. The completed weld is then brought to a 750°F post-heat and held for one hour.

This thermal history requirement complicates all of the fixture design and demands extreme caution to avoid thermal expansion distortion during welding that could adversely affect the geometry.

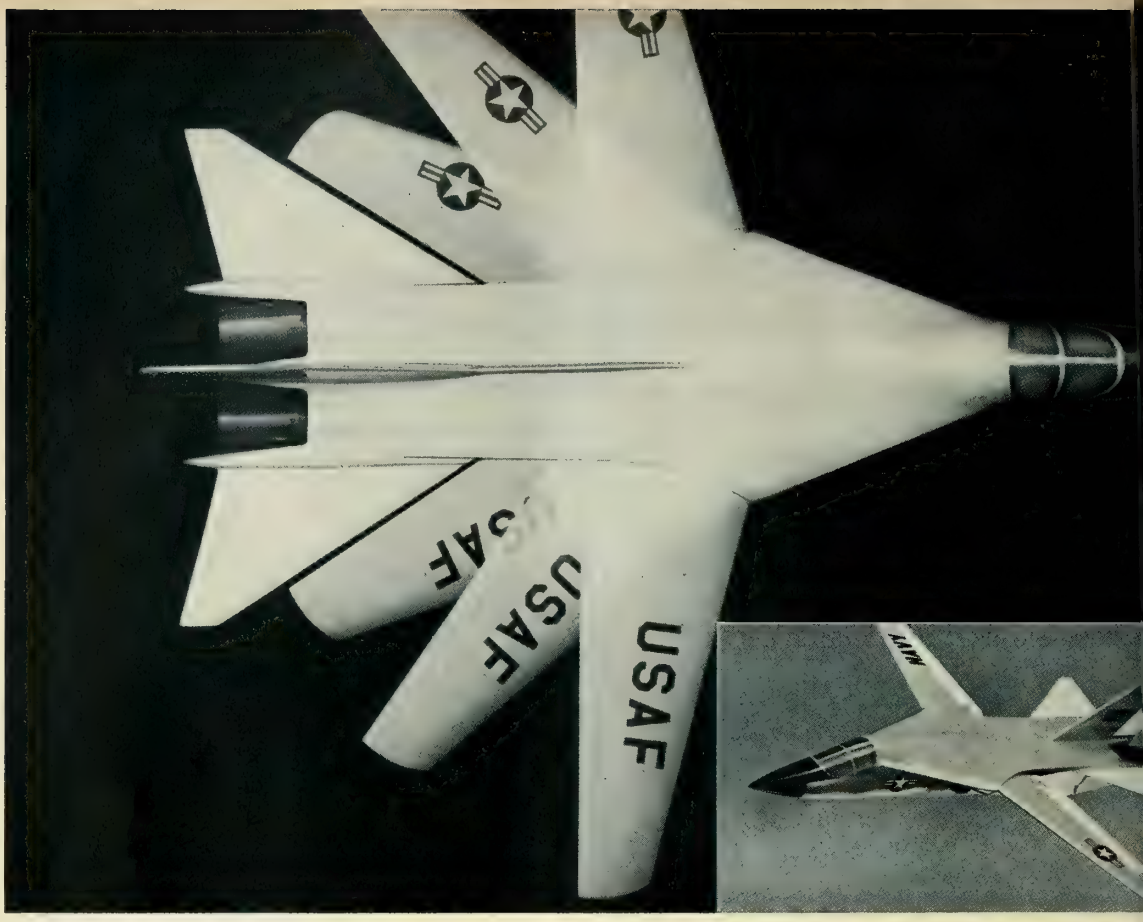
The Westinghouse approach to the domes involves the use of relatively thin plate—about 0.5 in.—which is spun over a mandrel into a hemispherical shape. The spinning operation does not generate a truly concentric shape or a precise contour on the dome.

Constant dome wall thickness is achieved using a Westinghouse-designed machine that turns the outside surface

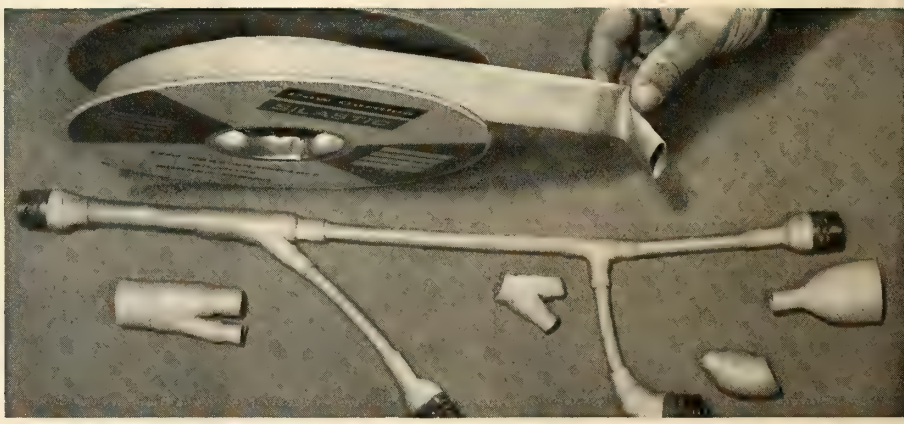
grees upward and 90 degrees around its axis—bringing the opening edge into a horizontal plane. Weld backup strips are laid behind the weld prep and the port ring placed in position.

The fixture backup ring is capable of moving radially outward insuring that the edge of the membrane to be welded seats on the backup strip. This procedure assures a minimum of mismatch. The weld is then performed by an automatic welder.

Heat treatment is subcontracted to the J. W. Rex Co., Lansdale, Pa., and requires salt quenching from 1600°F followed by tempering operations. Considerable shrinkage occurs in the D6AC caused by both metallurgical changes during the heat treating and the mass of individual components—the rings shrink more than the thin portions of the segments. Straightening and sizing rings are required during the final tempering operation. ■



News Briefs



A new heat-shrinkable silicone rubber, supplied in the form of finished parts by Dow Corning, shrinks to one-half its original diameter when heated briefly at 300F. Silastic® 1410 heat-shrinkable rubber provides tight, form-fitting protection for wire harnesses, cable splices, miliconductor cables, hydraulic and mechanical couplings, or acts as cab blast shields in rocket launching applications. Afte shrinking, this material retains its flexibility fro —100 to 500 F. Available in a range of stock tubin sizes or as custom made parts of varying shapes.

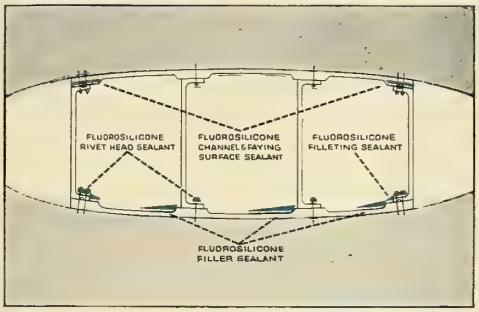
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New fluorosilicone rubber sealants seal integral fuel tanks on F-111

A new family of one-part fluorosilicone rubber sealants, developed by Dow Corning for the aerospace industry is meeting the needs for fuel resistant seals in high performance aircraft. Because of their flexibility and strength while immersed in jet fuel at temperatures from −70 to 500 F, four of these sealants were selected by General Dynamics for use in sealing critical areas of the integral fuel tanks in the F-111 Air Force/Navy tactical fighter.

A special fluorosilicone sealant which air cures to a resilient rubber was developed for use in filleting, another for rivet head and fastener coverings. Low spots that would form natural sumps are filled with a low density fluorosilicone sealant. Finally a *non-curing* sealant was designed for channel and faying surfaces.

The three sealants which cure to a strong rubber retain peel and bond strength after prolonged immersion in jet fuels or when subjected to splash and fume exposure of rocket fuels such as nitrogen tetroxide or hydrazine. All have excellent resistance to ozone, oxygen, many chemicals, weather, aging and thermal cycling. These fuel tank sealants are simply examples of Dow Corning's ability to engineer products for specific aerospace applications.



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New non-corrosive sealants, for aerospace applications, are now available from Dow Corning. These one-component sealants cure at room temperature to tough silicone rubber without liberating acetic acid; therefore are not noxious when used in confined areas. Common aerospace *structural* metals and materials show no corrosive reaction to these new sealants. They can be used for bonding, sealing, encapsulating, and coating surfaces which require heat, age and weather resistance. These sealants are ideal for construction of missiles and rockets as well as for on-site maintenance.

For further information about materials described here . . . or our capability to provide you with tailor-made materials designed specifically to meet your requirements, write Dept. 6209, or call Aerospace Materials Dept., Dow Corning, Midland, Michigan.

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Mars Exploration Decisions Due Soon

WITHIN THE NEXT few months the space agency must make two major decisions that will shape U.S. policy on the exploration of Mars.

Increasing pressure is being brought to bear on a top-level basis to make Mars a major scientific goal. Several authoritative scientific groups, including the National Academy of Sciences Space Board and the American Institutes of Biological Sciences, have made this recommendation. Other scientific groups are expected to speak soon, as the FY 1966 budget is being prepared.

The first decision is whether to launch a major scientific assault on Mars in 1971, which from a scientific standpoint offers the most advantageous view. While NASA has now ruled out a 1969 soft landing, the 1971 mission could actually view the same things as one launched two years before.

The other decision, to be made shortly, is whether to orbit Mars in 1969 or flyby the planet and eject a small re-entry capsule. Some biologists feel that an orbiter, which would get information over a larger area and a longer period of time, would be more rewarding in the long run.

● **Lander studies**—The 1971 opportunity for a soft landing is excellent in terms of least energy required, and the seasonal situation is one in which the dark areas—which many believe contain vegetation or primitive life of some sort—are well developed. The 1973 opportunity also ranks high in this regard.

NASA's Office of Space Sciences has begun studies to determine what kinds of payload would be best fitted to search for life on Mars. According to NASA Biosciences chief Dr. Orr Reynolds, the problem is this: scientists do not want to violate the planet too many times, since each landing lessens confidence in the sterile condition of the planet. Thus, NASA is looking for a payload that would require the least number of landings and yet give the most assurance of a true answer.

● **Possible experiments**—Philco Aeronutronic is now looking at the entire spectrum of instruments that could be integrated into one "Automated Biological Laboratory " (ABL). The following are the chemical experiments (Phase 2 B) NASA has asked the company to look at:

—Detection of proteins, including enzymes. Instruments could include gas chromatograph, mass spectrograph, and absorption spectrophotometer. NASA has also asked the company to consider a ultraviolet spectrophotometer and the multivator, experiments which have been developed by other investigators.

—Detection of nucleic acids. NASA has suggested optical rotation (polarimeter) mass spectrograph, gas chromatograph, and absorption spectrophotometer.

—Detection of other organic substances (sugar, aldehydes, alcohols, organic acids, lipids, etc.). The same instruments could be used for this purpose.

—Detection of inorganic elements, (nitrogen, phosphorus, chlorine, sulfur, sodium, calcium) which are associate with living systems. Again the sam instruments could be employed.

Biological experiments (Phase 2 A include:

—Morphology. Television and vidi con microscope could be used to giv data on form and structure.

—Physiology. NASA has asked th contractor to put emphasis on micro organisms in terrestrial or planetary derived media. Such experiments coul include 1) detection of the presence o enzymes during or after growth wit an instrument such as the multivato 2) catabolic carbon dioxide produc tion such as with the Gulliver, 3) evi dence of growth or turbidity, as wit the Wolftrap and multivator, 4) evi dence of photo-autotrophy and 5) evi dence of phosphorus incorporation.

In the same contract, Philco will loo at minimal spacecraft experiments, study related to that being carried ou by Jet Propulsion Laboratory.

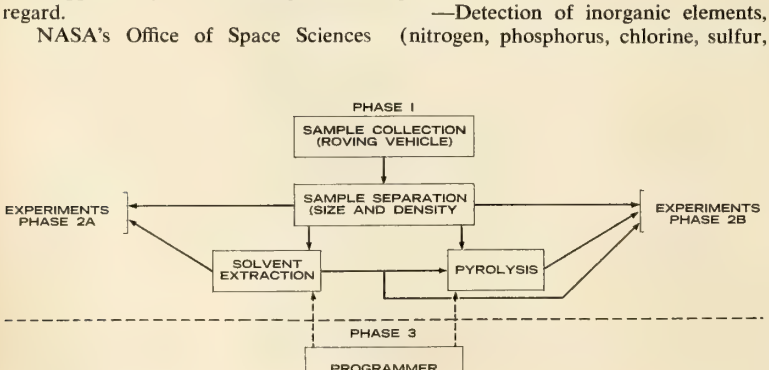
Although NASA has asked Philc to look at the various experiments whic have already been developed, there i no requirement that these be include in Philco's recommendations.

If a policy decision to go ahead wit the Automated Biological Laborator is made, "scientific RFP's" or calls fo experiments will go out to the scientifi community after the study.

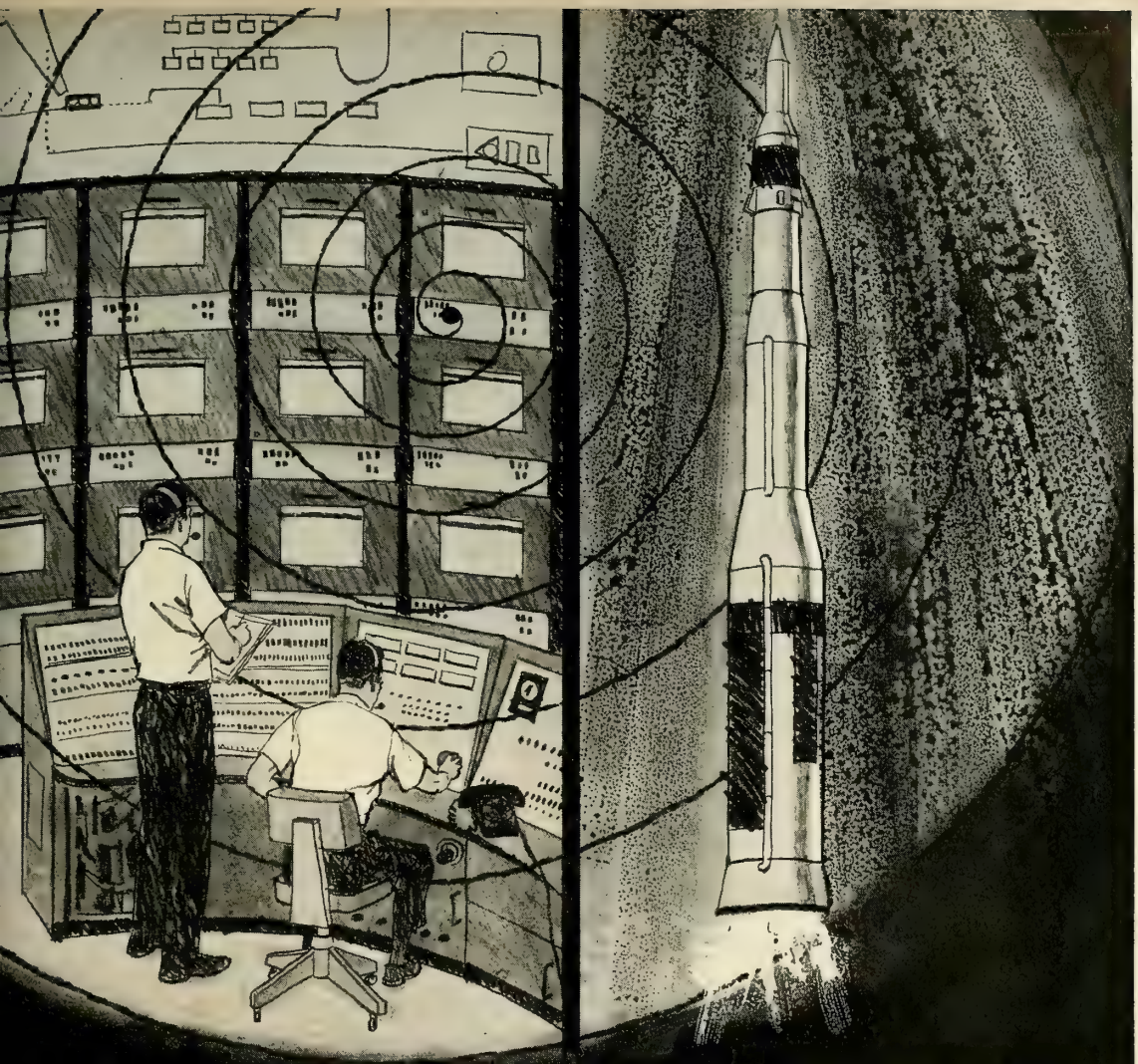
● **Pave way**—If the space agenc should choose an orbiter for the 196 Mars mission, a great deal could b learned in preparation for the lande

An *ad hoc* working group on th problem, headed by Dr. Carl Saga of the Harvard College Observator and Smithsonian Astrophysical Ob servatory, said that there are promis ing possibilities for determining phys ical parameters of biological rele vance. The group said these prospect ranked high: 1) obtaining high topo graphical resolution, 2) observing th surface at phase angles greater tha 43 degrees (and thus the night hemi sphere of Mars), and 3) detecting sea sonal changes on Mars. The group em phasized that a long lifetime—from fou to six months—would be desirable.

The ideal situation, the group re ported, would be an orbiter that func tions for a six-month period centere on heliocentric longitude 10 degrees. A highly elliptical orbit would also be ad vantageous. ■



PROCESS FLOW for Office of Space Sciences Automated Biological Laboratory.



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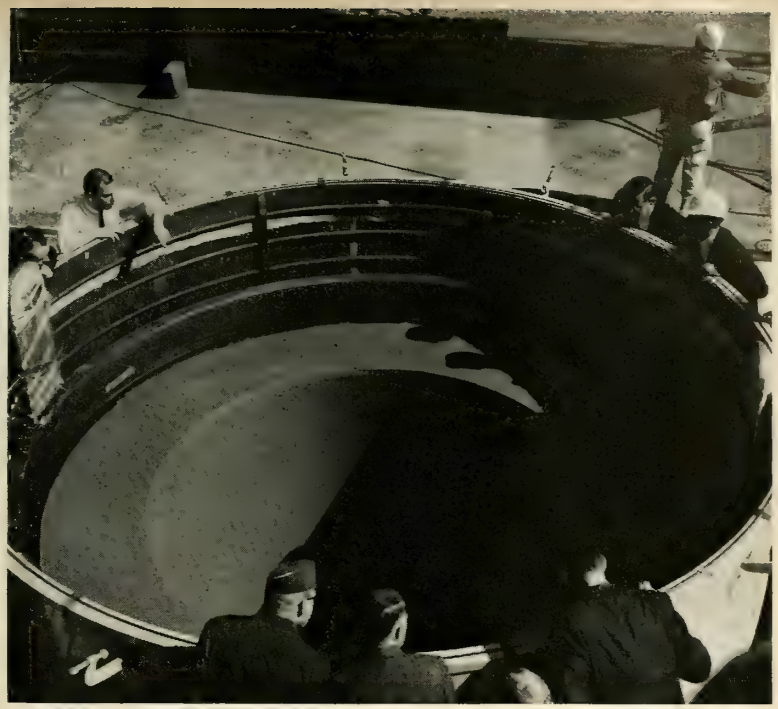


Coming ■ the one-for-all space guidance system. In the past, each new space mission has meant development of a new guidance system, requiring precious time and large expenditures. ☐ Now, to provide maximum reliability and performance at the least cost, Sperry is studying development, under government sponsorship, of a single "core" universal space guidance system, with optional "building block" add-ons for a wide span of missions in a wide variety of space vehicles. This new design will offer accuracy and reliability, with system flexibility. The in-depth experience for this new concept—inertial guidance and control, infra-red optics, digital and analog techniques, radar, displays and system management—is all "under one roof" at Sperry. **INERTIAL DIVISION, Sperry Gyroscope Co., Great Neck, New York.**

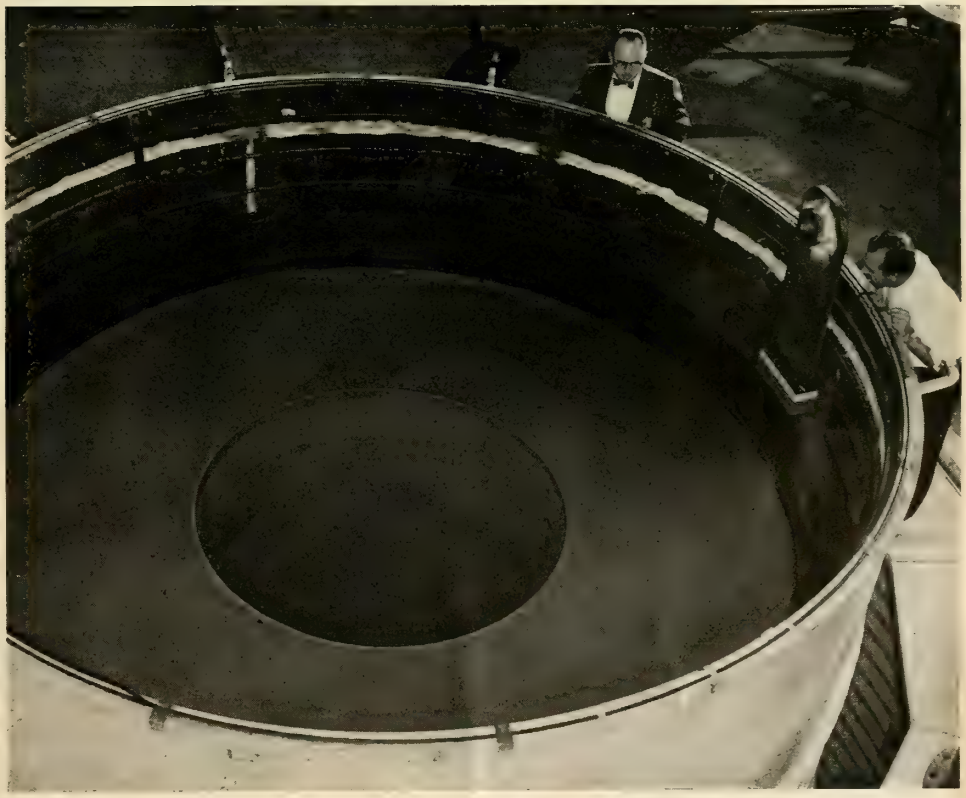
SPERRY
DIVISION OF
SPERRY RAND
CORPORATION

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Lockheed Prepares For Second 156-inch Solid Firing



LOCKHEED PROPULSION officials and representatives from the Air Force Space Systems Div. examine newly cast center segment of the second 156-in.-dia. demonstration motor. Segment alone contains more than 130 tons of rubber-based solid propellant. Motor is now being assembled for firing this fall. Entire case is same one used in May 28 test. Motor will have more than 650,000 lbs. of propellant.



THIS IS the same center segment before May 28 firing. Note difference in core diameter compared with second casting in top photo. Motors are cast at the Redlands, Calif., facility and transported to Lockheed's Potrero test installation for firings.



STRUCTURAL COMPONENTS. Lockheed now employs beryllium in sections of the skin o the Agena D—the first large-scale use of beryllium sheet. It has replaced magnesium panels becau of significant weight savings made possible by beryllium's high elastic modulus. BERYLCO ha cooperated closely with Lockheed in developing large sheet panels which can be formed an fabricated to aerospace structural configurations and quality requirements.

BERYLCO REPORTS...

Now the bright promise

Over the years, few metals have attracted more interest than beryllium—its unique properties explain why. Experience gained through time spent in continuous development now has turned what was once a laboratory curiosity into a practical design material. Today, beryllium invites serious consideration for use in virtually every aerospace project.

BERYLCO has contributed to this progress in two major ways. One, by applying its resources to advance techniques in beryllium processing and fabrication. Two, by offering a broad range of commercially available mill products. We invite you to discuss the ways in which we can apply these capabilities to your present programs.

For example, BERYLCO has contributed to the application of beryllium in a wide spectrum of aerospace programs, in such areas as instrumentation, optical apparatus, nuclear reactors, structures, space radiators, pressure vessels and jet aircraft brake and engine components. These uses perhaps suggest many others, particularly where beryllium's unique properties can be effectively applied. Due to beryllium's high stiffness-to-weight ratio, it is receiving increased attention for use as a structural material. This lightweight metal compares in density to magnesium, yet its modulus is six to seven times greater.

While aluminum and magnesium alloys melt at slightly over 1200°F, beryllium still maintains its *structural integrity* beyond these temperatures.

Availability of a wide range of shapes and forms enables beryllium to be at the core of new design concepts, rather than a substitute for another material. BERYLCO offers commercial quantities of beryllium in the form of hot pressed and machined products, extruded forms such as rod, bar, tubing and other structural configurations, wire, forgings, shee in gages .010 to .250 inches, in sizes u to 36″ by 96″.

Shown here are some of the many way in which beryllium is solving critica aerospace design problems. For tech nical literature on beryllium, or fo direct technical assistance, write to Th Beryllium Corporation, Dept. X9, Bo 1462, Reading, Pennsylvania 19603.

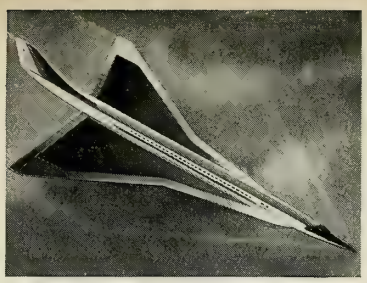
BERYLCO®

Developers and producers of extraordinary materials

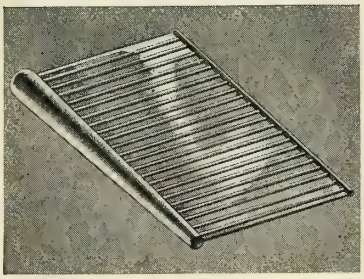
Beryllium • Beryllium Copper • Beryllium Nickel
Beryllium Aluminum • Beryllium Oxide

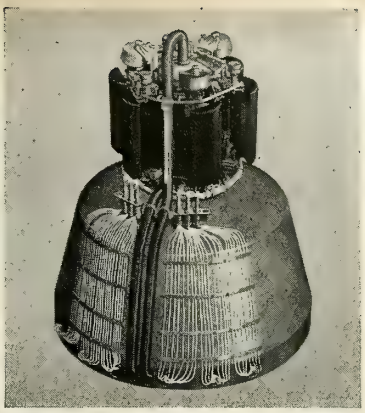
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BRAKE SYSTEMS. Beryllium brake applications are being developed for mach aircraft, stemming from the need for lighter weight and optimum heat dissipation. From room temperature to 2000°F, beryllium's heat capacity is some 4 to 5 times greater than steel. Possibilities: a heat-sink package with equal given size and heat absorbing potential . . . at a fraction of steel's weight; alternatively, a brake system with radically higher heat absorption, with no increase in total weight over steel.

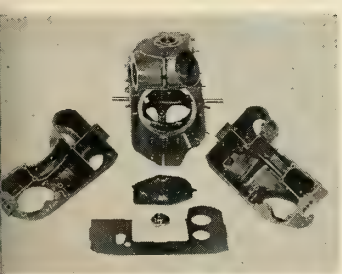




SPACE REACTORS. SNAP 8 is a 35-kilowatt electrical power supply for use on spacecraft. It employs a nuclear reactor heat source to drive a mercury Rankine cycle turboalternator. The reactor is being developed for the A.E.C. by Atomics International, a division of North American Aviation, Inc. Surrounding the reactor core vessel is a beryllium neutron reflector and six Be reflector control drums which maintain proper coolant outlet temperature by controlling reactor power. Beryllium's low thermal neutron capture cross section and high scatter cross section, coupled with resistance to moderately high temperatures, makes it ideally suited for this application.

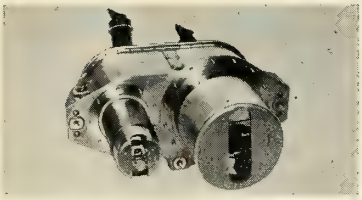
SPACE RADIATORS. Operation of turboelectric solar and nuclear space power systems requires heat rejection through large radiating surfaces. Designs are being developed for beryllium radiators because of its high thermal conductivity/density ratio. Beryllium in radiating fins and tube armor results in lowest specific weight (lb./kw) in operating temperature ranges of both Rankine and Brayton cycle systems.

of BERYLLIUM is being fulfilled



IDANCE AND CONTROLS. Beryllium s emerged in the past few years as the most ceptable material used in precision guidance d navigation systems. Its high ratio of ffness to density, inertness, and thermal coefient of expansion are responsible. For iner- l instrument use, beryllium must meet usually stringent specifications requiring tallurgical stability, homogeneity and lack porosity, because beryllium parts usually required to contain liquids or light gases.

T ENGINES. Higher operating efficiencies hrough higher thrust-to-weight ratios—are ssible with beryllium in jet engine compres- s. High strength levels, together with low nsity, make beryllium attractive for use in ding, shafting and discs. Titanium, long a ple in blades, is 2½ times heavier.



ASTRONAVIGATION. An astronavigational sextant and scanning telescope are contained in a single unit, with a beryllium housing and optical base. It was selected for high dimensional stability, light weight and excellent thermal properties. BERYLCO cooperated closely with the developer of this highly-precise instrument for the Apollo program, Kollsman's Space Division.

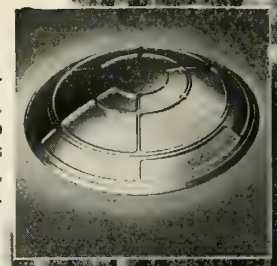




PRESSURE VESSELS. This sphere is a pressure bottle forged from beryllium. Projected application is for liquid rocket fuels. High strength at minimum weight was the design objective. This product is typical of what is being done today with the wide variety of forms in which beryllium is available.

CHEM-MILL

—a magnesium radar reflector. B&P is a licensee of Turco Products, Inc. with facilities for Chem-Milling magnesium, aluminum, and titanium.



MAGNESIUM-LITHIUM ALLOY LA141A Drawn Part

—B&P not only supplies the rolled sheet but also makes parts and assemblies of this lightest weight metal alloy.



AXIAL LOAD BULGE FORMING

—Shown is a typical part made by this process. B&P is exclusive licensee of Boeing Co., developer of the process.



B&P can offer you unusual subcontractor capabilities, here are but a few...



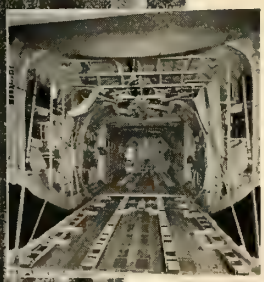
TITANIUM SKIN—END-GRAIN BALSA CORE

(Adhesive Bonded) sandwich is the material used by B&P in making this assembly.

ELECTRICAL DISCHARGE MACHINING

of holes in Beryllium. B&P has EDM facilities for machining and drilling hard-to-machine metals.





LIGHTWEIGHT AERIAL DELIVERY SYSTEMS

—designed, developed and produced by B&P for use by the U. S. Air Force and U. S. Army.

ELECTROPLATING AND ANODIC FINISHING

of magnesium are among B&P capabilities. Chromium, tin, silver, copper, gold and nickel are plated on magnesium; HAE, Dow 17 and Fluoride Anodize are also available.



b·p

Thorough knowledge of metals including *Aluminum, Magnesium, Beryllium, Magnesium-Lithium Alloy LA141A, Titanium, Zirconium, Boral*

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ASTROLOG

Current status of U. S. missile and space programs



Satellites and Spacecraft

ADVANCED ORBITING SOLAR OBSERVATORY (NASA)—CONTRACTORS: Republic, prime. DESCRIPTION: 1,200-lb spacecraft to make detailed measurements of Sun's solar radiation; greater pointing accuracy than OSO; launch vehicle, THRUST AUGMENTED THOR-AGENA. STATUS: Two spacecraft will be launched in 1968.

ADVANCED TECHNOLOGICAL SATELLITE (NASA)—CONTRACTORS: Hughes, prime. DESCRIPTION: Five-satellite program to test communication and meteorological equipment at medium and synchronous orbit; test bed for gravity gradient experiments; weight, 650 lbs.; launch vehicle, ATLAS-AGENA. STATUS: Development; first flight scheduled for 1966.

APOLLO (NASA)—CONTRACTORS: North American, command & service modules, systems integration; Grumman, Lunar Excursion Module (LEM); MIT, guidance development; Collins Radio, telecommunications; Honeywell, stabilization & control; AiResearch, environmental control; Northrop-Ventura, parachute recovery; Lockheed Propulsion Co., escape tower rocket; Marquardt, reaction contols; IBM, realtime computer complex; Westinghouse, power conversion equipment. Lunar Excursion Module, prime, Grumman; descent engine, Rocketdyne & TRW Space Technology Laboratories; ascent engine, Bell Aerosystems; environmental control, Hamilton Standard; reaction control thruster, Marquardt; guidance, MIT; radar & communications instruments, RCA; TMC, telemetry, Radiation Inc; fuel cell, Pratt & Whitney; external visual display, Forand Optical; DESCRIPTION: Three-man spacecraft for Earth-orbital, lunar-orbital and lunar-landing missions. Boosters: SATURN I and SATURN IB for Earth orbits; SATURN V for lunar rendezvous and landing missions; 3-modular spacecraft: Command Module weight, five tons; Service Module, 23 tons, Lunar Excursion Module, 12.75 tons; total weight, 85,000 lbs. STATUS: Unmanned Earth orbital shots started in 1964; lunar orbits scheduled 1968; lunar landing by 1970; first manned orbital flight due last half of 1966.

ASSET (Air Force)—CONTRACTORS: McDonnell Aircraft Corp., prime; Honeywell, guidance. DESCRIPTION: Aerothermodynamic/elastic Structural Systems Environmental Tests for various materials combinations during re-entry; delta-shaped re-entry vehicle; two versions planned weighing 1,100 lbs. (4 vehicles) and 1,200 lbs. (2); Length, 68.7 in.; span, 58.9 in. STATUS: Development; program to be expanded to study different shapes, materials, etc. One AMR shot in September, 1963, successful although vehicle not recovered; second vehicle successfully launched and recovered, July 22; START program, an expanded research effort in glide entry, is now being formulated.

BIOS (NASA)—CONTRACTORS: GE, prime. DESCRIPTION: 1,000-lb. Satellites to test effects of space environment on plants, animals (primates) and other biological specimens; launch vehicle, THRUST-AUGMENTED DELTA. STATUS: Six flight models to be built; first flight in December, 1965; others to follow at three-month intervals; first experiments selected in February.

COMSAT CORP. SATELLITE PROGRAM—CONTRACTORS: Studies being performed by Hughes, TRW with ITT, and AT&T and RCA as joint contractors. STUDIES: AT&T/RCA, 18 satellites, medium-altitude random orbit; STL/ITT, 12 satellites, medium altitude, controlled orbit using gravity gradient stabilization; Hughes 2nd generation synchronous orbit system. STATUS: First satellites to be in orbit by mid-1966, with entire system operational by mid-1967.

DISCOVERER (Air Force Program 622A)—CONTRACTORS: Lockheed, prime; GE, re-entry vehicle. DESCRIPTION: THOR-AGENA and ATLAS-AGENA launchings of stabilized satellites; main purpose is to test techniques and components for military space systems. STATUS: All data on program classified as part of DOD information policy; however, indications are that program has been cut back or ended as more economical vehicles have come into use.

EARLY BIRD (ComSat Corp.)—CONTRACTORS: Hughes, prime. DESCRIPTION: Experimental modified syncom to be placed in 22,300-mi. stationary orbit and provide 240 two-way telephone channels between U.S. and Europe or simultaneous transmission of 22 or more telegraph messages; booster, THRUST-AUGMENTED DELTA. STATUS: Development; contract calls for delivery of first satellite by April, 1965; launch scheduled for mid-1965.

ECHO (NASA)—CONTRACTORS: Langley Research Center, prime. DESCRIPTION: ECHO I, 135-ft. inflatable sphere in 700- to 805-mi. orbit; passive communication satellite; THOR for ballistic tests; THOR-AGENA for orbital. STATUS: Program complete; ECHO I in orbit since Aug. 12, 1960; two ballistic shots in 1962 unsuccessful. ECHO II launched from Vandenberg Jan. 27; U.S.-USSR conducting series of cooperative experiments using ECHO.

GEMINI (NASA)—CONTRACTORS: McDonnell, prime; Rocketdyne, spacecraft propulsion; General Electric, fuel cell; IBM, guidance system integration and computer; Honeywell, guidance; Westinghouse, rendezvous radar; AiResearch, environment. DESCRIPTION: Bigger and heavier MERCURY-type capsule to carry two men for up to two weeks; TITAN II to be used as booster; ATLAS-launched AGENA will be used for rendezvous missions; 15 spacecraft will be produced. STATUS: Development; 12 flights planned; will be used to determine feasibility of rendezvous for lunar mission and long-duration manned flight; first unmanned flight, April, 1964, successful; second postponed to late 1964 after lightning damaged GT-2 in August; manned and rendezvous flights, 1965-67; AF participating in program, and will modify GEMINI Capsules for MANNED ORBITING LABORATORY.

HYPERSONIC RESEARCH VEHICLE (AF, NASA)—CONTRACTORS: None announced. DESCRIPTION: Manned, hypersonic spacecraft capable of Earth-to-orbit-and-return; turbofan, Mach 0-3; ramjet, Mach 3-6 or 7 (oxygen collected and liquefied during this cycle); Mach 8-10 orbital speeds, LH_2-LOX rocket. STATUS: Joint NASA-AF research program approved; NASA funding $2.5 million in FY '65; AF has advanced technology program in six pertinent areas (mostly engine developments in FY '65.

ICBM ALARM (Formerly MIDAS) (Air Force Program 239A)—CONTRACTORS: Lockheed, prime; Aerojet, IR detector system. DESCRIPTION: Early-warning random orbit satellite; detect ICBM launchings by IR; two flights conducted in 1963 detected solid and liquid missile launches; satellites are launched piggy-back on various AF boosters. STATUS: Development; no decision on deployment; reportedly competing with over-the-horizon radar.

INTERPLANETARY MONITORING PLATFORM (NASA)—CONTRACTORS: Goddard Space Flight Center, prime; Martin Co. developing nuclear power unit. DESCRIPTION: 140-lb. satellite launched into deep-space orbit with an apogee of 172,000 mi.; will measure radiation and solar flare hazards in advance of Project APOLLO; launched by DELTA booster from AMR. STATUS: Program calls for five more satellites with next launch in late 1964; two to be placed in lunar orbit; later flights will use a nuclear power unit as replacement for solar cells; Designation IMP-A is EXPLORER XVIII.

ISIS (Canada, U.S.)—CONTRACTORS: Canadian Defense Research Board, satellite; NASA, launch vehicle. DESCRIPTION: Three-satellite follow-on program to ALOEUTTE to continue ionospheric studies. STATUS: Design of ISIS A to begin this year with launch in 1967; B and C to be launched in 1968, 1969.

LUNAR LOGISTICS SYSTEM (NASA)—CONTRACTORS: Studies have been conducted by Grumman, TRW/STL and Northrop. DESCRIPTION: Spacecraft to carry support payloads to the Moon. Two designs under study—LEM Truck with 7,000-lb payload and logistics spacecraft with 25,000 to 30,000 lb. payload; booster: SATURN V. STATUS: Program decision expected 1964; no funding expected until FY '66; program would cost about $1 billion.

LUNAR ORBITER PHOTO CRAFT (NASA)—CONTRACTORS: Boeing, prime; RCA, power and communications; Eastman Kodak, cameras. DESCRIPTION: 800-lb. spacecraft launched by ATLAS-AGENA will orbit Moon taking pictures of lunar surface; radioactive and geodetic measurements will also be taken. STATUS: Ten flights scheduled beginning in 1966.

MANNED ORBITING LABORATORY (Air Force)—CONTRACTORS: Study contracts awarded to Douglas, GE, and Martin on the ORBITING SPACE STATION (OSS); also contracts for studies of selected sub systems. DESCRIPTION: Two-man spacecraft to establish military usefulness of man in space; booster, TITAN III; GEMINI-B capsule atop 10 ft.-dia., 20-ft.-long canister lab; total weight about 18,000 lbs.; orbit below 350 mi.; flights of 30 days in shirt-sleeve environment planned. STATUS: Pre-program definition; RFPs expected to be issued in March, 1965; unmanned GEMINI launch early 1966; unmanned canister launch late 1967, manned first half 1968; rendezvous capability possible later.

MARINER (NASA)—CONTRACTORS: Jet Propulsion Laboratory, prime. DESCRIPTION: 570-lb. unmanned spacecraft for early interplanetary missions to vicinity of Mars and Venus; boosted by ATLAS-AGENA B. STATUS: First scheduled Venus fly-by, August, 1962, unsuccessful after booster failure; second passed within 21,594 mi. of Venus, Dec. 14; two Mars fly-by missions planned in late 1964; because of press of maintaining APOLLO schedules, NASA has dropped plans for 1966 Mars shot; Agency will concentrate efforts on heavier spacecraft for 1969 window.

MDS (NASA)—CONTRACTORS: Fairchild Stratos, prime. DESCRIPTION: 3,400-lb. meteoroid-detection satellite employing two 50 x 15-ft. extendable detector wings; Earth orbit 300 to 800 mi.; booster, SATURN I. STATUS: Development; will measure size, energy and frequency of meteoroids to evaluate hazards of impact with manned spacecraft; first launch scheduled for third quarter 1964; two other MDS will be launched as part of SATURN I development program.

MEDIUM ALTITUDE COMMUNICATIONS SATELLITE (Program 369) (AF, DCA, Army)—CONTRACTORS: Philco, prime. DESCRIPTION: Multiple-launch, random, active repeater comsat; 16-24 satellites launched in groups of 6-8 satellites in 19,000 n.mi. polar orbits; weight about 100 lbs.; TITAN-IIIC booster. STATUS: Negotiations with ComSat Corp. have been broken off and DOD will develop own system; MACS, an "interim" system is to be in operation in 1966.

NATIONAL ORBITING SPACE STATION (NASA, AF)—CONTRACTORS: Many studies awarded. DESCRIPTION: Manned space station with orbital lifetime of one to five years for testing components and techniques in the space environment; weight ranges under study vary from 15,000-20,000 up to 200,000 lbs. STATUS: Decision not expected for one to four years; EXTENDED APOLLO, AF MANNED ORBITING LABORATORY, MANNED ORBITING RESEARCH LABORATORY and LARGE ORBITING RESEARCH LABORATORY being considered.

NIMBUS (NASA)—CONTRACTORS: Goddard Space Flight Center, prime; GE, integration and testing; RCA, videcon cameras. DESCRIPTION: 830-lb. second-generation weather satellite; Earth-stabilized polar orbiting; TV cameras and IR scanners in payload; THOR-AGENA B booster. STATUS: First launching successful August 28; picture & IR quality good in spite of satellite's elliptical orbit; second, scheduled for launch within a year; two R&D satellites to be funded in FY '65; uses Automatic Picture Transmission system.

NUCLEAR DETECTION SATELLITES (Formerly Vela) (ARPA)—CONTRACTORS: TRW Space Technology Laboratories, prime; Los Alamos Scientific Lab/Aerospace Corp., payload. DESCRIPTION: 20-sided, 485-lb. satellite for detection of nuclear explosions in space; 50,000-mi. orbit; booster, ATLAS-AGENA; launched in pairs. STATUS: First pair successfully launched in October, 1963; second pair successfully launched July 17, 1964; three pairs remain.

OAO (NASA)—CONTRACTORS: Grumman, prime; Westinghouse, ground station, components; GE, stabilization and control; Kollsman, star trackers; IBM, data processor and storage; Hughes and Avco, communications equipment. DESCRIPTION: 3,600-lb. orbiting astronomical satellite to study ultraviolet spectrum from approximately 1,200 A to 4,000 A; four major experiments selected; one piggyback; booster, ATLAS-AGENA D. STATUS: Three flights beginning in late 1965.

OGO (NASA)—CONTRACTORS: TRW Space Technology Laboratories, prime; DESCRIPTION: 1,000-lb. satellite with instruments for geophysical measurements; polar (POGO) and eccentric (EGO) shots planned; can carry more than 20 experiments; ATLAS-AGENA B, THRUST-AUGMENTED THOR boosters. STATUS: First launch on Sept. 4 partially successful; 14 of 20 experiments working.

OSO (NASA)—CONTRACTORS: Ball Brothers, prime; DESCRIPTION: OSO 1,458-lb. orbiting solar observatory; OSO II, 535-lbs.; DELTA booster; S-16 early version; S-17 and S-57 advanced versions. STATUS: First flight Mar. 7, 1962, highly successful; first flight for S-17 planned for second quarter 1964 delayed until 1965; five more flights planned.

PIONEER (NASA)—CONTRACTORS: TRW Space Technology Laboratories. DESCRIPTION: 140-lb. spin-stabilized solar probe; augmented DELTA launch vehicle; cylindrical; covered with 10,000 solar cells; four outrigger booms for stabilization; five experiments, 60 to 90-million-mi. communication capability. STATUS: Seven launches in program; early 1965 launch schedule set; orbits range from 0.8 to 1.2 au for 6-mo. lifetime; ADVANCED PIONEER under study.

RANGER (NASA)—CONTRACTORS: JPL, prime; Hercules, retro-rocket; Northrop, support contractor; RCA, TV system. DESCRIPTION: Before impact, TV cameras take pictures of lunar surface; ATLAS-AGENA B booster. STATUS: RANGER VI launch Jan. 30; TV system failed; RANGER VII launched July 28 and impacted moon after transmitting 4,316 pictures back to earth; RANGER VIII scheduled for Jan., 1965, with IX two months later; this will complete Ranger program.

RELAY (NASA)—CONTRACTORS: TRW Space Technology Laboratories, project coordination and systems planning; RCA, prime. DESCRIPTION: 172-lb. spin-stabilized wideband 800 to 4,600-mi.-orbit active repeater experimental communications satellite. DELTA booster. STATUS: Britain, France, Brazil and Germany building ground stations; first launch, Dec. 13, 1962; RELAY II launched Jan. 21, 1964; program completed.

SAMOS (Air Force Program 720A)—CONTRACTORS: Lockheed, prime; photo intelligence equipment, Eastman Kodak; capsules, GE; parachute and guidance recovery equipment, Avco and Northrop Ventura. DESCRIPTION: Reconnaissance satellite; formerly SENTRY; R&D model weighs 4,100 lbs. with E-5 capsule (3,000 lbs. with E-6); ATLAS-AGENA booster; 100-300-mi. circular polar orbit. STATUS: Operational; advanced SAMOS under development; FERRET version used for electronic intelligence and communications eavesdropping.

SATAR (Air Force)—CONTRACTORS: General Dynamics, prime. DESCRIPTION: 300-lb. scientific satellite pod mounted on side of ATLAS booster; length, 55 in.; diameter 27 in.; 200-lb. payload; orbits vary from 500 to 2,000 n. mi.; as re-entry vehicle, gains speeds up to 30,000 fps; guidance, strap-down system with three orthogonally-mounted gyros; unstabilized when in orbit. STATUS: Development; seven vehicles being built under present contract; pods of SATAR type have been flown on 44 missions.

SATELLITE INSPECTOR (Air Force PROGRAM 706)—CONTRACTORS: None. DESCRIPTION: Satellite inspection system consisting of a spacecraft capable of co-orbital inspection of non-cooperative satellites. STATUS: Re-oriented from unmanned vehicle to manned satellite using GEMINI; Conceptual preliminary design studies under way; early GEMINI flights expected to provide important inputs; $2 million in FY '65 budget.

SECOR (Army)—CONTRACTORS: ITT Labs, prime; Cubic Corp., transponder. DESCRIPTION: 40-lb. geodetic satellite; rectilinear, measuring 9 x 11 x 14 in.; can be carried piggyback on a variety of boosters; frequency, 162-324 mc for geodetic measurements; 54-216 mc for refraction studies. STATUS: Operational; third launch took place early this year on AF secret satellite.

SERT I (NASA)—CONTRACTORS: RCA, prime. DESCRIPTION: Spinning ballistic test vehicle carrying two electric-propulsion engines for environmental tests. STATUS: First flight July 20 from Wallops Island, Va., carried a Lewis election bombardment engine and a Hughes contact ionization engine; the Lewis engine worked well while Hughes engine produced no thrust.

SURVEYOR (NASA)—CONTRACTORS: Hughes, prime; Martin, SNAP device. DESCRIPTION: 2,100-lb. spacecraft for soft-landing 100-300 lbs. of instruments on Moon; nine 2,500-lb. spacecraft are also planned; ATLAS-CENTAUR booster; SNAP nuclear generator optional. STATUS: First Moon flights late 1965; five soft-landing vehicles planned in Block I series.

SYNCOM (NASA)—CONTRACTORS: Hughes, prime. DESCRIPTION: 24-hr. orbit instantaneous narrow band, active repeater communications satellite; 28-in. in dia. and weighs about 63 lbs.; DELTA booster; capable of accommodating one full duplex radio telephone channel. STATUS: First launch failed, Feb. 14, 1963; satellite believed to be in orbit but contact lost; SYNCOM II launched July 26, 1963, completely successful; third launch Aug. 19 successful; satellite is to be positioned in stationary orbit over Pacific to relay 1964 Olympic Games to U.S. from Japan; program now complete.

SMS (Synchronous Meteorological Satellite) (NASA)—CONTRACTORS: Republic, RCA Astro-Electronics; Hughes, study contracts. DESCRIPTION: 24-hr. weather satellite, Earth-stabilized; TV cameras with variable focus; may use SNAP-50 for power; booster may be ATLAS-AGENA or -CENTAUR. STATUS: Studies to continue; development funds not included in FY '65 budget.

TELSTAR (AT&T, NASA)—CONTRACTORS: Bell Telephone Laboratories, management for AT&T. DESCRIPTION: 170-lb. active repeater experimental industry communication satellite; DELTA booster. STATUS: Development; first launch July 10, 1962, highly successful; second launch May 7, 1963, also successful; program now complete.

TIROS (NASA, Weather Bureau)—CONTRACTORS: RCA, prime. DESCRIPTION: 285-lb. meteorological satellite; TV pictures of cloud cover; sensors to gather heat balance data; one TIROS to be tested for steerability in highly elliptical orbit (300-3,000 mi.). STATUS: R&D; eight vehicles launched; all successful; five more launches planned with TIROS in new configuration (earth stabilized) to serve as an interim National Operational System.

TRANSIT (Navy)—CONTRACTORS: Applied Physics Laboratory, prime; Martin, SNAP device; Westinghouse, shipboard satellite signal receivers. DESCRIPTION: Navigational satellite; R&D model over 250 lbs.; operational, 50 to 100 lbs.; operational system; four satellites in random, near-circular 600-mi. orbits; SNAP nuclear generator; ABLESTAR booster. STATUS: Operational system established for use by POLARIS subs and surface ships; two nuclear-powered (SNAP-9A) satellites launched in 1963; NASA exploring feasibility of commercial system.

TRS (Air Force)—CONTRACTOR: TRW/STL. DESCRIPTION: 3-lb. scientific satellite to measure radiation; four-sided, measuring 9 in. on a side. STATUS: Operational; first launched piggyback on DOD payload 10/17/63.

VOYAGER (NASA)—CONTRACTORS: Study contracts, Avco and GE. DESCRIPTION: Unmanned MARINER follow-on spacecraft to orbit Mars and VENUS and to eject a capsule to the surface. STATUS: Development funds not included in FY '65 budget; launches in 1971-73 period; spacecraft of 6,000 lbs. to be launched by three-stage SATURN IB, TITAN III or SATURN V.

X-15 (NASA, AF, NAVY)—CONTRACTORS: North American, prime; Thiokol, propulsion; Sperry Gyroscope, inertial flight data system; Honeywell, adaptive flight control electronics. DESCRIPTION: Manned rocket plane capable of 4,000-mph-plus flight at edge of space; single rocket engine develops 57,000 lbs. thrust. STATUS: Powered flights in progress; unofficial records set—altitude 354,200 ft. and speed 4,104 mph; hypersonic propulsion research program should run through 1968; more than 100 flights have been made; ramjet (X-15A2) flights scheduled for 1968.



Space Vehicles

ABLESTAR (Air Force)—CONTRACTORS: Space General, prime; Aerojet, propulsion; Space General/Bell Telephone, guidance. DESCRIPTION: 2,000-lb. upper stage; 9.5 ft. long; 55 in. dia.; radio command guidance; propellants, UDMH/IRFNA; restart capability; STATUS: Used in TRANSIT and other military programs; THOR booster.

ATLAS-AGENA D (Air Force)—CONTRACTORS: General Dynamics/Astronautics, (ATLAS); Lockheed (AGENA); TRW/STL, AGENA B; Honeywell, inertial reference. DESCRIPTION: 275,000-lb. booster; payload capability, 5,000 lbs., in 345-mi. orbit, 750 lbs. to escape, 40 lbs. for planetary missions; length, 102 ft.; base diameter, 10 ft.; liquid propulsion; modified Atlas D with 360,000-lb. thrust; Agena B with 15,000-lb. thrust; restart capability. STATUS: Operational; used in RANGER, DISCOVERER, MACS, MARINER, LUNAR ORBITER, OAO, SAMOS and other programs.

AGENA D (Air Force)—CONTRACTORS: Lockheed, prime; Honewell, guidance; Bell, propulsion. DESCRIPTION: 1,700-lb. upper stage; 25 ft. long; 5 ft. dia.; all-inertial guidance; propellants, UDMH/IRFNA; multiple re-start capability; ATLAS, THOR and THOR augmented boosters. STATUS: Used in DISCOVERER, SAMOS and other military programs as well as a variety of NASA programs; e.g., MARINER, RANGER, OAO and OGO.

CENTAUR (NASA)—CONTRACTORS: Lewis, program management; General Dynamics/Astronautics, prime; Pratt & Whitney, propulsion; Honeywell, guidance. DESCRIPTION: High-energy upper stage using a pair of RL-10 LOX/liquid hydrogen engines; 30,000 lbs. total thrust; 30 ft. long; 10 ft. dia.; ATLAS D booster; capable of orbiting 8,500 lbs.; 2,300 lbs. to escape; 1,300 lbs. on planetary flights. STATUS: Development; first test flight failed; second launch Nov. 27, 1963, highly successful; third, June 20, 1964, partially successful; two more launches planned in 1964 and six in 1965 when the vehicle is to become operational.

DELTA (NASA)—CONTRACTORS: Douglas, prime; Bell Telephone Labs, guidance; Rocketdyne/Aerojet/Allegany Ballistics Laboratory, propulsion. DESCRIPTION: Successor to THOR-ABLE; upper stage guidance; three-stage vehicle; 800-lb. payload capability in 100-mi. orbit; THRUST-AUGMENTED DELTA payload capability 1,500 plus lbs. in 100-mi. orbit; THOR missile comprises first stage. STATUS: launch vehicle for TIROS, EXPLORER, OSO, BIOS, ECHO; TAD used for SYNCOM & PIONEER; 26 previously on order augmented by AF order for 21 more for NASA; THRUST-AUGMENTED DELTA with three solid motor strap-ons also being used.

LITTLE JOE II (NASA)—CONTRACTORS: General Dynamics/Convair, prime. DESCRIPTION: Solid-propelled vehicle with 800,000-lb. thrust; launch vehicles for APOLLO suborbital flights. STATUS: Two launches Aug. 28, 1963, and May 13, 1964, successful; six vehicles ordered thus far; third launch scheduled for Dec., 1964.

POST-SATURN V LAUNCH VEHICLE (formerly NOVA) (NASA)—CONTRACTORS: Studies. DESCRIPTION: Capability of Nova under study; no firm concept but should offer significant improvement over C-5 (20-30 million-lb. first-stage thrust large solid motors, and nuclear upper stage under consideration). STATUS: Study to determine characteristics; operational target date post-1970.

PROJECT FIRE (NASA)—CONTRACTORS: Republic, re-entry package; Ling-Temco-Vought, velocity package; General Dynamics/Astronautics, launch vehicle and systems integration. DESCRIPTION: Re-entry probe to measure environmental heating at lunar return speeds (25,000 mph); launch vehicle, Atlas D plus Antares II A-5 (re-entry booster). STATUS: R&D: first flight April, 1964, successful; second flight scheduled for mid-1965.

PROJECT SCANNER (NASA)—CONTRACTORS: Honeywell, fabrication and integration; Baird-Atomic; star-mapper telescope; Santa Barbara Research Center, dual radiometers. DESCRIPTION: Unmanned scientific satellite to measure natural radiation gradients. STATUS: R&D.

ROVER (NASA, AEC)—CONTRACTORS: Los Alamos Scientific Labs, ROVER prime; Aerojet, NERVA prime; Westinghouse, propulsion. DESCRIPTION:

First nuclear rocket; tests of Kiwi, prototype of NERVA engine, under way. STATUS: Kiwi tests to be completed this year; development of Phoebus reactor initiated; no flight test program funded at present.

SATURN I (NASA)—CONTRACTORS: Systems engineering, assembly and guidance, Marshall Center; S-I stage, Chrysler Corp.; S-IV, Douglas. DESCRIPTION: Two-stage vehicle for early boilerplate tests of APOLLO and MDS; first stage: eight Rocketdyne H-1 engines; second stage: six Pratt & Whitney RL-10-A3 engines; 22,000 lbs. into 345-mi. orbit. STATUS: Four flight tests of first stage successful; all flights with inert upper stage; first flight with live upper stage successfully launched Jan. 27, putting 37,700 lbs. in low Earth orbit; SA-6 May 28, 1964, also successful; four more R&D flights planned to complete development effort.

SATURN I-B (NASA)—CONTRACTORS: Systems engineering, assembly and guidance, Marshall Center; S-I stage, Chrysler; S-IVB stage, Douglas. DESCRIPTION: S-I, eight H-1 engines; S-IVB, one J-2 engine; payload capability, 28,500 lbs. in 345-mi. orbit. STATUS: Development; first flight in 1966; boost APOLLO spacecraft boilerplate models, including lunar landing vehicle; first manned flight in APOLLO program set for late 1966; advanced version able to orbit 30 tons under consideration.

SATURN V (ADVANCED SATURN) (NASA)—CONTRACTORS: Systems engineering, assembly and guidance, Marchall Center; S-IC, Boeing; S-II, North American; S-IVB, Douglas; F-1, North American; J-2, North American. DESCRIPTION: S-IC, five F-1 engines; S-II, five J-2 engines; S-IVB, J-2 engine; 120-ton payload in 345-mi. orbit; 43 tons to escape velocity; 30 tons for planetary missions. STATUS: R&D; first flight scheduled for 1967; prime booster for APOLLO missions; may also be used to boost orbiting space station.

SCOUT (NASA)—CONTRACTORS: LTV Astronautics, prime; Honeywell, guidance; Aerojet/Thiokol/Allegany Ballistics Laboratory, propulsion. DESCRIPTION: Solid propulsion four-stage satellite launcher; 72 ft. long; 3.3 ft. dia.; 300-lb. payload in 345-mi. orbit; 80 lbs. to escape. STATUS: Operational; used by NASA for EXPLORER and other small payloads; also procured by NASA for Air Force as BLUE SCOUT; NASA has ordered 23 more boosters.

THOR-ABLE STAR (Air Force)—CONTRACTORS: Douglas, prime; Bell Telephone Labs, guidance; Rocketdyne, first-stage propulsion; Space/General, second; DESCRIPTION: Two-stage vehicle with 181,900 lbs. total thrust; performance, 900 lbs., in 100-n.-mi. orbit; length, 55.9 ft., diameter, 8 ft., weight, 118,200 lbs., height, 79 ft.; guidance, radio command; STATUS: Operational; used in TRANSIT and other military program.

THOR-AGENA D (Air Force and NASA)—CONTRACTORS: no prime; Douglas, THOR frame; Lockheed, AGENA D; Rocketdyne, propulsion. DESCRIPTION: Liquid-propulsion vehicle to put 1,600-lb. payload in 300-mi. orbit; length, 76 ft.; diameter, 8 ft.; launch weight, 123,000 lbs.; 172,00 lbs. thrust; THOR, radio guidance, AGENA, all-inertial. STATUS: Operational; used in AF space program; TELSTAR, Topside Sounder and other NASA programs; NASA has 11 launched scheduled.

THRUST-AUGMENTED DELTA (NASA)—CONTRACTOR: Douglas, prime; Thiokol, solid propulsion. DESCRIPTION: DELTA launch vehicle with three strap-on solids; performance, 1,000 lbs. to Earth orbit; 150 lbs. to escape; propulsion, three XM-33 solid motors producing 55,000 lbs. thrust each. STATUS: Development; to be used for BIOSATELLITE, PIONEER, SYNCOM, TIROS and COMSAT programs; initial flight in 1964.

THRUST-AUGMENTED THOR (Air Force/NASA)—CONTRACTORS: no prime; Rocketdyne, and Thiokol, propulsion. DESCRIPTION: THOR-AGENA with 3 strap-on solids; THOR liquid propulsion, 172,000 lbs. of thrust; each strap-on, 55,000 lbs. thrust; performance, 2,500 lbs. in 100-n.mi. orbit. STATUS: Operational; used for NIMBUS and POGO and others too heavy for THOR, but not heavy enough for ATLAS.

TITAN II (GLV) (NASA)—CONTRACTOR: Martin, prime. DESCRIPTION: Manned space booster; Essentially Titan II with addition of redundant electrical power and flight control systems; malfunction detection system and radio command guidance. STATUS: Development; GT-2 (unmanned version) to be launched late this year.

TITAN III (Air Force Program 624A)—CONTRACTORS: Martin, systems integration; United Technology, large solid boosters; Martin, TITAN II vehicle; Aerojet, liquid engines; Martin, standardized upper stage; AC Spark Plug, guidance. DESCRIPTION: Quick-reaction vehicle for military space missions; will be used to boost MOL/GEMINI B; Zero stage, two 120-in. solid motors; first and second stages, TITAN II (storable propellants); third-stage standardized vehicle to be developed; modified TITAN II guidance; payload, 25,000 lbs. in 100 n.mi. orbit, 2,100 to 22,300-mi. orbit; 5,000 to escape. STATUS: Development; first flight Sept. 1 (T-IIIA) achieved primary and secondary objectives, but failed to achieve orbit; January, 1965 (T-IIIC); 17 development flights planned; five TITAN II core vehicles (A version), 12 full TITAN III's (C version); operational in 1966; an unmanned rated version—Titan IIIX—being studied as more cost/effective booster for satellite launches.



Missiles

AADS-70 (Army)—CONTRACTORS: Hughes/Douglas/FMC, RCA/Beech, competitive component development contracts. DESCRIPTION: Field army ballistic missile defense system, mobile. STATUS: No decision to develop system has been made; component development funded at $5 million in FY '65; expected to provide basis for program definition in 1965.

ALFA (RUR-4) (Navy)—CONTRACTORS: Navy, prime; Avco, frame; Naval Propellant Plant, propulsion. DESCRIPTION: ASW, surface-to-underwater; weight, 500 lbs.; solid propulsion; H.E. depth charge; range, 900 yds.; guidance, free-flight. STATUS: Operational; deployed on destroyers and cruisers.

ANTI-SATELLITE WEAPON (Air Force)—CONTRACTORS: None announced. DESCRIPTION: Surface-to-air; THOR and THRUST-AUGMENTED THOR boosters; AGENA D second stage; radar-homing third stage. STATUS: Full-scale development; flight tests in late 1965 or early 1966.

ASROC (RUR-5A) (Navy)—CONTRACTORS: Honeywell, prime; Sangamo Electric, sonar; GE, torpedo; Librascope-General Precision, fire control. DESCRIPTION: ASW, surface-to-underwater; weight, 1,000 lbs.; solid propulsion; warhead, nuclear or conventional; range between 1,800 yds. and 8 mi.; guidance, unguided. STATUS: Operational on DE, DD, DLG, & heavy cruisers; one "live" weapon fired in Pacific nuclear tests; industry competition for extended range version expected this year.

ASTOR (Mk-45) (Navy)—CONTRACTORS: Westinghouse, prime. DESCRIPTION: Mark 45 ASW, underwater-to-underwater torpedo; weight, over 2,000 lbs.; solid propulsion; warhead, nuclear or conventional; range, about 11 n.mi.; guidance, wire. STATUS: In production; deployed on hunter-killer submarines.

ATLAS (PGM-15) (Air Force)—CONTRACTORS: TRW Space Technology Laboratories, systems engineering & technical direction; GD/Astronautics, frame; GE/Burroughs/Arma, guidance; Rocketdyne, propulsion; GE/Avco, re-entry vehicle. DESCRIPTION: ICBM; weight, 266,000 lbs.; liquid propulsion; warhead, nuclear; range, 5,500-9,000 mi.; ATLAS "E" and "F" series inertial guidance, ATLAS "D" radio inertial. STATUS: 13 squadrons operational at 11 bases; total number of missiles, 126; phaseout of ATLAS D's to begin in FY '65; ATLAS Standard Launch Vehicle being developed for AF space programs; ATLAS being used in conjunction with ATHENA launches at Green River, Utah, in an effort to develop scaling laws for re-entry bodies (Advanced Ballistic Re-entry Systems program).

BOMARC A (AIM-10A) (Air Force)—CONTRACTORS. Boeing, prime; IBM/Westinghouse, guidance; Aerojet/Marquardt, propulsion. DESCRIPTION: Surface-to-air interceptor; weight, 15,000 lbs.; liquid booster/ramjet propulsion; warhead, nuclear; range, 200 n.mi.; guidance, command via SAGE; speed, MACH 2.5; ceiling, over 68,000 ft. STATUS: All A missiles at five bases operational in northeastern U.S. to be phased out by the end of 1965; production completed; costs $20 million per year to operate system.

BOMARC B (AIM-10B) (Air Force)—CONTRACTORS: Boeing; prime; General Precision Aerospace/Westinghouse/IBM, guidance; Thiokol/Marquardt, propulsion. DESCRIPTION: Surface-to-air; weight, 16,000 lbs.; solid booster/ramjet propulsion; warhead, nuclear; range, more than 400 n.mi.; guidance, command via SAGE; speed, Mach 2.7. STATUS: Three bases operational production completed; the 188 B models will be distributed among the eight bases after the A model is phased out.

BULLPUP (AGM-12 B & C) (Navy-Air Force)—CONTRACTORS: Maxson Electronics Co., prime; AMF, liquid engine; Thiokol, solid propulsion; Naval Propellant Plant, solid propulsion (motor loading). DESCRIPTION: Air-to-surface; range, 3-6 mi.; guidance (visual reference), radio-link command. BULLPUP A: Solid propulsion; warhead, 250-lb. H.E. BULLPUP B: pre-packaged liquid motor; warhead, 1,000-lb. H.E. STATUS: BULLPUP A deployed with Atlantic and Pacific Fleets; operational with U.S. Air Force & NATO units; training version (ATM-12) being procured by both services; being produced in Europe for NATO.

CLOSE-SUPPORT ASSAULT WEAPON (Navy)—CONTRACTORS: Navy Bureau of Weapons and Johns Hopkins Applied Physics Lab, prime; United Aircraft Norden Div., guidance. DESCRIPTION: Ship-to-shore; outside dimensions compatible with TERRIER shipboard installations; solid propulsion; warhead, high explosive; range, 30-mi. minimum; guidance, inertial and terminal. STATUS: Carried as a line item in FY '66 budget; funding to some degree dependent on results of guidance system flight tests at WSMR aboard SERGEANT missiles.

CONDOR (AGM-53) (Navy)—CONTRACTORS: In-house; Naval Ordnance Test Station. DESCRIPTION: Air-to-surface; configuration classified. STATUS: Development; intended for use with Navy version of F-111.

CORPORAL (MGM-5) (Army)—CONTRACTORS: Firestone, prime; ITT-Gilfillan, guidance; Ryan, propulsion. DESCRIPTION: Surface-to-surface; weight, 11,000 lbs.; liquid propulsion; warhead, nuclear; range, 75 n.mi.; guidance, pre-set and command. STATUS: All units de-activated; replaced by SERGEANT

DAVY CROCKETT (M-388) (Army)—CONTRACTORS: In-house project directed by Army Weapons Command at Rock Island, Ill. DESCRIPTION: Surface-to-surface; solid propulsion, bazooka-launched; warhead, sub-kiloton nuclear; guidance, free flight; two launchers—vehicle-mounted or carried by two men. STATUS: Operational in Europe; $13 million provided in FY '64 budget; 3 per ROAD battalion; seen as defensive rather than offensive weapon to prevent overrun of Europe.

ENTAC (MGM-32) (Army)—CONTRACTORS: Nord Aviation, prime. DESCRIPTION: Anti-tank; weight, 37 lbs. with launcher; solid propulsion; warhead, shaped-charge H.E.; range, 6,600 ft.; guidance, wire-guided; man-portable. STATUS: Operational; procurement complete; will be replaced by TOW.

FALCON (AIM-4 A, C, E, F/26A/47A) (Air Force)—CONTRACTORS: Hughes, prime; Hughes, guidance; Thiokol, AIM-4/26 propulsion; Lockheed Propulsion, AIM-47 propulsion. DESCRIPTION: Air-to-air; weight (AIM-4/47), more than 100 lbs.—(AIM-26), more than 200 lbs.; range 5 n.mi.; supersonic; solid propulsion; warhead, H.E. (except for AIM-26); AIM-4A, and 4E, active radar homing guidance; AIM-4C, and 4F, IR homing; AIM-26 model has nuclear warhead and hybrid IR radar homing. STATUS: Operational; buy-out of 4E, 4F and 26 in FY '62; AIM-47 under development & being evaluated for YF-12A (A-11).

FLEET AIR DEFENSE MISSILE (Navy)—CONTRACTORS: None announced. DESCRIPTION: Surface-to-air. STATUS: Will replace standardized missile and use technology from TYPHON program; fleet defensive weapons for 1970's.

GENIE (AIR-2A) (Air Force)—CONTRACTORS: Douglas, prime; Aerojet-General, propulsion. DESCRIPTION: Air-to-air; weight 800 lbs.; unguided; solid propulsion; warhead, nuclear; range, 6 n.mi.; guidance, free flight; supersonic; proximity fuzing. STATUS: Procurement complete; operational on F-101B and F-106; improved version cancelled.

HAWK (MIM-23A) (Army)—CONTRACTORS: Raytheon, prime; Raytheon, guidance; Aerojet-General, propulsion. DESCRIPTION: Surface-to-air; weight, 1,275 lbs.; solid propulsion; warhead, H.E.; range, 22 mi.; guidance, semiactive radar homing; 100-45,000-ft. ceiling; provides defense against medium and low-flying aircraft and cruise-type missiles. STATUS: Operational; deployed in Europe, Panama, Okinawa, U.S. (13 battalions); bought by Sweden and Israel; R&D being conducted to adapt selected HAWK units to an anti-tactical ballistic missile; NATO producing.

HIBEX (ARPA/Army) CONTRACTORS: Boeing, prime; Hercules and Aerojet, propulsion. DESCRIPTION: Experimental program in high-energy propellants; cone shaped missile; performance classified; solid propulsion. STATUS: Development; accelerations of 800 to 1,000 g's goal; flight test program of 10 vehicles to be conducted at WSMR beginning late this year.

HONEST JOHN (MGR-1) (Army)—CONTRACTORS: Douglas/Emerson Electric, prime; Hercules, propulsion. DESCRIPTION: Surface-to-surface; weight, 5,900 lbs.; single-stage solid propulsion; warhead, nuclear; range, 12 mi. (M-31), 20 mi. (M-50); unguided. STATUS: Operational; M-50 being deployed in Europe; to be replaced by LANCE; procurement complete.

HOUND DOG (AGM-28) (Air Force)—CONTRACTORS: North American, prime; Autonetics, guidance; Pratt & Whitney, propulsion. DESCRIPTION: Air-breathing air-to-surface standoff missile; weight, 9,600 lbs.; turbojet propulsion; warhead, nuclear; range, about 600 n.mi.; guidance, inertial; ceiling in excess of 50,000 ft.; Mach 2+. STATUS: Operational; to be launched from B-52G intercontinental bombers; procurement complete.

LANCE (XMGM-52) (Army) CONTRACTORS: Ling-Temco-Vought, prime; Systron-Donner, guidance. DESCRIPTION: Highly mobile general-purpose missile; very light weight; pre-packaged storable liquid propellant; warhead, nuclear and H.E.; range, 3-30 mi.; guidance, Automet inertial, one missile per launcher. STATUS: Large-scale development; eventually will replace HONEST JOHN and LACROSSE and perhaps LITTLE JOHN; division support weapon; to use multi-system test equipment.

LITTLE JOHN (MGR-3) (Army)—CONTRACTORS: Emerson Electric, prime; Hercules Powder, propulsion. DESCRIPTION: Surface-to-surface; weight, 800 lbs.; solid propulsion; warhead, nuclear; range, 10-mi.; unguided; supplements medium and heavy artillery in airborne divisions and air-transportable commands. STATUS: Two battalions activated in 1961; each equipped with four launchers; air and helicopter transportable; may be replaced by LANCE.

LOW ALTITUDE SUPERSONIC VEHICLE (Air Force)—CONTRACTORS: Ling-Temco-Vought, nuclear vehicle components; AEC/Marquardt, nuclear and chemical technology; Lockheed, studies of chemical version. DESCRIPTION: Surface-to-surface, low-altitude; nuclear or chemical ramjet; designed to conduct long aerial patrols at speeds up to 2,000 mph. STATUS: Nuclear propulsion system being developed under project PLUTO; feasibility proven by TORY reactor tests Tory II-C tests in May, 1964 highly successful exceeding all expectations; program cancelled in July, 1964 for lack of a requirement.

M72 (Army)—CONTRACTORS: Hesse-Eastern Div., Flightex Fabrics, prime. DESCRIPTION: Light antitank rocket; weight, 4.5 lbs.; solid propulsion; warhead, H.E.; range, 500 yds.; guidance, free flight; carrier tube launcher; earlier called LAW. STATUS: Operational.

MACE (MGM-13A, CGM-13B) (Air Force)—CONTRACTORS: Martin, prime; Goodyear/AC Spark Plug, guidance, Thiokol/Allison, propulsion. DESCRIPTION: Air-breathing surface-to-surface; weight, 18,000 lbs.; turbojet and solid propulsion; warhead, nuclear and H.E., range, over 650 n.mi. (Model A), over 1,200 n.mi. (Model B); guidance, Map-matching (A), Inertial (B). STATUS: Five MACE-A and one MACE-B squadron (in hard sites) deployed in Europe; two MACE-B squadrons on Okinawa in hard sites.

MATADOR (MGM-1C) (Air Force)—CONTRACTORS: Martin, prime; Air Force, guidance; Thiokol/Allison, propulsion. DESCRIPTION: Air-breathing surface-to-surface; weight, 10,000 lbs.; turbojet and solid propulsion; warhead, nuclear or H.E.; range, over 600 n.mi.; guidance, MSQ radar and form of LORAN; speed, about 650 mph.; ceiling above 35,000 ft. STATUS: West Germans and Nationalist Chinese employing system.

MAULER (MIM-46) (Army)—CONTRACTORS: GD/Pomona, prime; Hughes, guidance; Lockheed, propulsion; deHavilland, IR acquisition; Raytheon, radar; Burroughs, computer; FMC, carrier vehicle. DESCRIPTION: Surface-to-air; weight, 120 lbs.; solid propulsion; warhead, nuclear, H.E.; guidance, IR acquisition; highly mobile antiaircraft and antimissile missile; tracked vehicle; 9 missiles per launcher. STATUS: Development; suffering serious packaging problems: Army postponing more advanced models until after feasibliity validation program has determined if system can be saved.

MAW (Army)—CONTRACTORS: McDonnell Aircraft Co. and Army Missile Command, development of competitive approaches to Medium Anti-Tank/Assault Weapon requirement; Ford Instrument Co., gyro package for Army version. DESCRIPTION: Surface-To-Surface; solid propellant; range, 500-1,500 yds.; shoulder-fired; McDonnell version wire-guided; Army version two-degree-of-freedom, free rotor gyro. STATUS: Exploratory Development; Competitive approaches to be fired off against each other in Summer 1965 and the best allowed to proceed into full-scale development.

MINUTEMAN (LGM-30) (Air Force)—CONTRACTORS: TRW Space Technology Laboratories, systems engineering and technical direction; Boeing, major contractor; Autonetics, guidance; Thiokol first-stage propulsion; Aerojet, second-stage propulsion; Hercules, third-stage propulsion; Avco, re-entry vehicle. DESCRIPTION: 2nd-generation ICBM; weight, over 65,000 lbs.; solid propulsion; warhead, nuclear; 3 stages; range, over 5,000 mi.; guidance, all-inertial, target selected in seconds; 32-sec. reaction time. STATUS: MINUTEMAN II under development; 600 MINUTEMAN I now operational; 1,000 missiles through FY '65; advanced version can be fired by airborne command posts; deployed in hardened and dispersed silos; MINUTEMAN II expected operational 1965, to be co-located with MMI; also some of the II's replace earlier models; MMII has greater accuracy and range payload than I version.

MOBILE MEDIUM-RANGE BALLISTIC MISSILE (Air Force)—CONTRACTORS: (development phase) Hughes, integration, assembly and checkout; Philco Aeronutronic, re-entry system; Thiokol, propulsion; Goodyear Aerospace Corp., transporter-launcher-erecter; Martin Marietta, command and control; General Precision, guidance. DESCRIPTION: Two-stage MRBM; weight, 11,000 lbs.; solid propellent; range, 1,100-2,000 mi.; guidance, stellar-inertial; entire system contained in one mobile vehicle; STATUS: Lack of deployment objective or valid military requirement has caused Congress to cut $70 million from $110 million requested; DOD cancelled the program in August, 1964 except for command & control and guidance system developments.

NIKE-HERCULES (MIM-14B) (Army)—CONTRACTORS: Western Electric, prime; Western Electric, guidance; Hercules and Thiokol, propulsion; Douglas, airframe. DESCRIPTION: Surface-to-air, antiaircraft, tactical; weight, 10,000 lbs.; solid propulsion; warhead, nuclear or H.E.; range, 75-mi.; guidance, command; Mach 3+; ceiling in excess of 150,000 ft. STATUS: Over 80 batteries deployed in U.S. being turned over to National Guard; over 10 N-H batteries deployed overseas; being equipped with HIPAR, a high power acquisition radar, and anti-tactical-ballistic-missile capabilities. Re-location of some Hercules batteries under consideration by JCS.

NIKE-ZEUS (XLIM-49) (Army)—CONTRACTORS: Western Electric, prime; Bell Telephone, guidance; Thiokol/Lockheed, propulsion; Douglas, airframe. DESCRIPTION: Antimissile missile, 3-stage; weight, 22,800 lbs.; solid propulsion; warhead, nuclear; range, 200-mi.; guidance, command; length, 48 ft.; diameter, 36 in.; fin span, 10 ft. STATUS: Missile to become part of NIKE-X missile "mix"; development, except as part of X, has ended; no intercept "failure" in more than a year of tests.

NIKE-X (Army)—CONTRACTORS: Western Electric, prime; Bell Telephone, guidance; Thiokol, ZEUS propulsion; Douglas, ZEUS airframe; Martin Marietta, SPRINT missile prime; Hercules and Lockheed, SPRINT propulsion. DESCRIPTION: Successor to ZEUS as an anti-ICBM system; uses a mix of ZEUS/SPRINT missiles and multi-function array radar (MAR). STATUS: Engineering development; funded at $334 million in FY '65 on accelerated development schedule, but deployment still deferred; tests to be conducted late this year with MAR at WSMR, New Mexico, could provide basis for deployment decision; deployment costs: $12-20 billion.

PERSHING (MGM-31) (Army)—CONTRACTORS: Martin, prime; Bendix guidance; Sperry Farragut, fuzing and aiming; Thiokol, propulsion. DESCRIPTION: Surface-to-surface; weight, 10,000 lbs.; two-stage solid propulsion; warhead, nuclear; range, approx. 400 n.mi.; guidance, intertial; transported on FMC M474 tracked vehicles; replaced REDSTONE. STATUS: Flight test program completed; troop firings from Ft. Wingate, N.M., to White Sands being conducted; number of launches per unit to be increased; West Germany organizing two battalions; first U.S. PERSHING battalion deployed to Germany in April.

PHOENIX (AIM-54) (Navy)—CONTRACTORS: Hughes Aircraft Co., prime; Rocketdyne, propulsion. DESCRIPTION: Air-to-missile for use with the F-111B fighter aircraft; each aircraft will be able to carry six missiles. STATUS: Development; also to be tested for use on A-11 aircraft.

POLARIS (UGM-27 A, B, C) (Navy)—CONTRACTORS: Lockheed, prime; GE/MIT/Hughes/Honeywell/Raytheon, guidance and fire control; Aerojet-General/Hercules, propulsion; Lockheed, re-entry vehicle; Nortronics, checkout; Autonetics/Sperry, SINS; Westinghouse, launching equipment; Vitro, systems engineering coordination and training; Systron-Donner, ignition programming. DESCRIPTION: Underwater- and surface-to-surface; weight, 30,000 lbs.; solid propulsion; warhead, nuclear; range, 1,200 n.mi. (A-1), 1,500 n.mi. (A-2), 2,500 n.mi. (A-3); guidance, all-inertial. STATUS: 16 operational each with 16 missiles; A-1 aboard first five submarines; A-2 operational aboard subs 16-18; A-3 to be operational in August 1964 aboard subs 19-23; total of 41 POLARIS subs authorized; deployed in Atlantic and Mediterranean; Pacific deployment to begin by end of year; British to buy A-3 missiles from US. B-3 program definition included in FY '65 budget.

QUAIL (ADM-20C) (Air Force)—CONTRACTORS: McDonnell, prime; McDonnell Electronics, guidance; GE, propulsion; Thompson Ramo Wooldridge, ECM equipment. DESCRIPTION: ECM-carrying decoy which simulates B-52 bomber to enemy radar; turbojet powered; range, 250 mi.; guidance, gyroscopic autopilot. STATUS: Deployed at SAC bases; carried by B-52; procurement completed FY '61; advanced version with 400-mi.-range has been flight tested.

REDEYE (MIM-43) (Army)—CONTRACTORS: GD/Pomona, prime; Hughes, IR seeker; Atlantic Research, propulsion. DESCRIPTION: Surface-to-air; weight, 22 lbs.; solid propulsion; warhead, conventional; guidance, IR-homing; length, 44 in.; diameter, 2.75 in. STATUS: Development to continue; Congress denied FY '65 procurement request; could be restored by Senate; growth versions planned.

REDSTONE (PGM-11) (Army)—CONTRACTORS: Chrysler, prime; Sperry Farragut, guidance; Rocketdyne, propulsion. DESCRIPTION: Surface-to-surface; weight, 62,000 lbs.; liquid propulsion; warhead, nuclear; range, 200 mi.; guidance, inertial. STATUS: No units remaining in inventory; replaced by PERSHING.

REGULUS I (RGM-6) (Navy)—CONTRACTORS: Ling-Temco-Vought prime; Sperry, guidance; Allison, propulsion. DESCRIPTION: Surface-to-surface; weight, 14,000 lbs.; turbojet and solid propulsion; warhead, nuclear; range, 500 n. mi.; guidance, inertial; speed, about 600 mph; ceiling, approx. 40,000 ft. STATUS: Five REGULUS subs with 17 missiles are operational now; 3 subs (8 missiles) will be phased out in FY '65.

SERGEANT (MGM-29A) (Army)—CONTRACTORS: Sperry Utah, prime; Sperry guidance; Thiokol, propulsion. DESCRIPTION: Surface-to-surface; weight, 10,000 lbs.; solid propulsion; warhead, nuclear; range, over 75 n. mi.; guidance, inertial; uses drag brakes. STATUS: Operational; procurement complete; deployed in Europe; replacement for CORPORAL; West Germany buying system.

SHILLELAGH (MGM-51A) (Army)—CONTRACTORS: Philco Aeronutronic, prime; Picatinny Arsenal/Amoco Chemicals Corp., propulsion; Aeronutronic, guidance. DESCRIPTION: Surface-to-surface; lightweight; solid propulsion; warhead, nuclear or H.E.; guidance, command; vehicle-mounted for use against field fortifications, armor and for close-in support of troops. STATUS: Initial procurement in FY '65; to use multi-system test equipment; engineering development stage began in FY '64; to be installed on Gen. Sheridan assault vehicle; also being considered for use on helicopters.

SHRIKE (AGM-45A) (Navy)—CONTRACTORS: Naval Ordnance Test Station-China Lake, prime; Texas Instruments, guidance and control; North American Rocketdyne (McGregor), propulsion. DESCRIPTION: Air-to-surface, anti-radar; solid propulsion; guidance, passive radar homing; formerly ARM. STATUS: Operational; armament for Navy and Air Force tactical aircraft.

SIDEWINDER I-C (AIM-9D) (Navy, Air Force)—CONTRACTORS: Naval Ordnance Test Station, technical direction; Philco, guidance; Naval Ammunition Depot, McAllister, motor loading; Rocketdyne (McGregor), propellant. DESCRIPTION: Air-to-air; weight, about 155 lbs.; solid propulsion; warhead, H.E.; range, more than 2 mi.; guidance, IR. STATUS: 1A deployed with Navy and Air Force; 1-C version being procured as replacement for 1A; NATO-built version now in production.

SPARROW III-6B (AIM-7E) (Navy)—CONTRACTORS: Raytheon, prime; Raytheon, airframe, control, guidance; Aerojet-General/North American Rocketdyne (McGregor), propulsion; McDonnell/Benrus Watch Co., launcher. DESCRIPTION: Air-to-air; weight, 350 lbs.; solid propulsion; warhead, conventional; range, 5-8 mi.; guidance, semi-active CW homing; Mach 2.5-3; ceiling, over 50,000 ft. STATUS: Earlier models operational with carrier aircraft; SPARROW III-6B prime armament for Phantom II (F-4B) and other high-performance interceptors.

SPRINT (Army)—CONTRACTORS: Martin-Orlando, prime; Hercules Powder/Lockheed Propulsion Co., propulsion; Bell Telephone Laboratories, guidance. DESCRIPTION: High-acceleration missile for low-altitude interception of ballastic missiles; nuclear; missile will be popped out of silo before motor is ignited; to be part of the missile mix in a NIKE-X battery. STATUS: Development; SQUIRT vehicle to be used to test materials and components for SPRINT at White Sands Missile Range.

STANDARDIZED MISSILE (Navy)—CONTRACTORS: Boeing, GE, Hughes, Raytheon, Sperry Rand, RCA, Westinghouse. DESCRIPTION: Surface-to-air. STATUS: Program Definition; to be standard replacement for TALOS, TERRIER and TARTAR.

SUBROC (UUM-44A) (Navy)—CONTRACTORS: Naval Ordnance Laboratory, technical direction; Goodyear, prime; General Precision Aerospace, guidance; Thiokol, propulsion; General Precision Librascope, fire control. DESCRIPTION: Underwater-air-underwater antisubmarine missile-depth bomb; solid propulsion; warhead, nuclear; range, 25-30 mi.; guidance, inertial. STATUS: Production; scheduled for installation in Thresher-class subs; will be operational this year.

SS-10 (Army)—CONTRACTORS: Nord Aviation, prime; GE, U.S. licensee. DESCRIPTION: Surface-to-surface, primarily antitank; weight, 33 lbs.; solid propulsion; warhead, conventional; range, 1,600 yards; wire guided. STATUS: Operational with U.S., French and other NATO and Western units; battle-tested in North Africa; U.S. replacing with ENTAC.

SS-11 (Army)—CONTRACTORS: Nord Aviation, prime. DESCRIPTION: Surface-to-surface antitank, also helicopter-to-surface; weight, 63 lbs.; solid propulsion; wire guided; warhead, conventional; range, 3,800 yds. STATUS: Operational, to be used with airborne units and Army helicopters.

TACTICAL PROBE (Navy)—CONTRACTORS: Bendix, prime. DESCRIPTION: Surface-to-air; multiple, interchangeable payloads for each mission; booster, TERRIER or TALOS from shipboard installations; high-impulse second stage; range, 50-300 mi.; parachute descent. STATUS: Program definition; Navy told by DOD to restudy requirements and come up with a cheaper program.

TALOS (RIM-8E) (Navy)—CONTRACTORS: Bendix, prime; Vitro, systems engineering; Bendix/McDonnell/Hercules Allegany Ballistics Lab., propulsion; Sperry, guidance; GE, launching gear. DESCRIPTION: Ship-to-air; weight, 7,000 lbs.; solid and ramjet propulsion; warhead, nuclear; range, 65 n. mi.; guidance, radar beam riding/semi-active homing; Mach 2.5. STATUS: Operational aboard cruisers Galveston, Oklahoma City and three heavy cruisers; Long Beach, nuclear-powered cruiser, has advanced TALOS; "3-T" get-well program increasing reliability.

TARTAR (RIM-24B) (Navy)—CONTRACTORS: Vitro, systems coordination engineering; Applied Physics Lab, design and development; GD/Pomona, assembly and test; Raytheon, guidance; Aerojet-General, propulsion (motor loading); Sperry Farragut, fuze (target detection device). DESCRIPTION: Ship-to-air; weight, 1,500 lbs.; solid dual-thrust motor; warhead, conventional; range, 10 n. mi.; guidance, beam-riding; Mach 2. STATUS: Operational; installed aboard 15 guided missile destroyers and cruisers equipped with TALOS; get-well program progressing satisfactorily.

TERRIER (RIM-2E) (Navy)—CONTRACTORS: Vitro, systems engineering; GD/Pomona, prime; GD/Pomona, guidance section; Sperry, radar; Hercules Allegany Ballistics Laboratary, propulsion; Northern Ordnance, launching gear. DESCRIPTION: Ship-to-air; weight, 3,000 lbs.; 27 ft. long; solid propulsion; warhead, conventional; range 10 n. mi.; guidance, radar beam-riding or homing; Mach 2.5. STATUS: Operational aboard two attack carriers, 6 cruisers, and 12 missile frigates; get-well program progressing satisfactorily.

TITAN I (HGM-25A) (Air Force)—CONTRACTORS: TRW [illegible] Technology Laboratories, systems engineering and technical direction; Martin, prime; Bell/Sperry, guidance; Aerojet-General, propulsion [illegible] re-entry vehicle. DESCRIPTION: ICBM; weight, 220,000 lbs.; LOX/RP-1 fueled; warhead, nuclear; range, 5,000 mi.; guidance, radio inertial; 90 ft. long; 2 stages. STATUS: Operational; 54 missiles at 5 bases.

TITAN II (LGM-25C) (Air Force)—Martin, prime; TRW Space Technology Laboratories, system engineering and technical direction; AC Spark Plug, guidance; Aerojet-General, propulsion; GE, re-entry vehicle. DESCRIPTION: ICBM; weight, 330,000 lbs.; N_2O_4 and Aerozine-50 storable fuels; warhead, nuclear; range, over 5,000 mi.; guidance, inertial; 115 ft. long; 2 stages; greatest payload and range of any U.S. ICBM; basic core vehicle for TITAN III booster. STATUS: All 54 missiles operational; one squadron (18 missiles) operational at Davis-Monthan AFB; one (18 missiles) at McConnell AFB and one (18 missiles) at Little Rock AFB.

TOW (Army)—CONTRACTORS: Hughes, prime. DESCRIPTION: Antitank; weight, 160 lbs.; solid propulsion; warhead, H.E.; wire guided; optically tracked; tube-launched. STATUS: Development; follow-on to ENTAC; firings being conducted at Army Missile Command.

WALLEYE (Navy)—CONTRACTORS: Navla Ordnance Test Station, China Lake. DESCRIPTION: Guided air-to-surface bomb; weight, 1,000 lbs., equipped with movable fins; propulsion type, none; warhead, high-explosive; range, several miles; guidance, TV contrast homing guided by pilot. STATUS: Engineering development; industry invited to bid on production of missile.

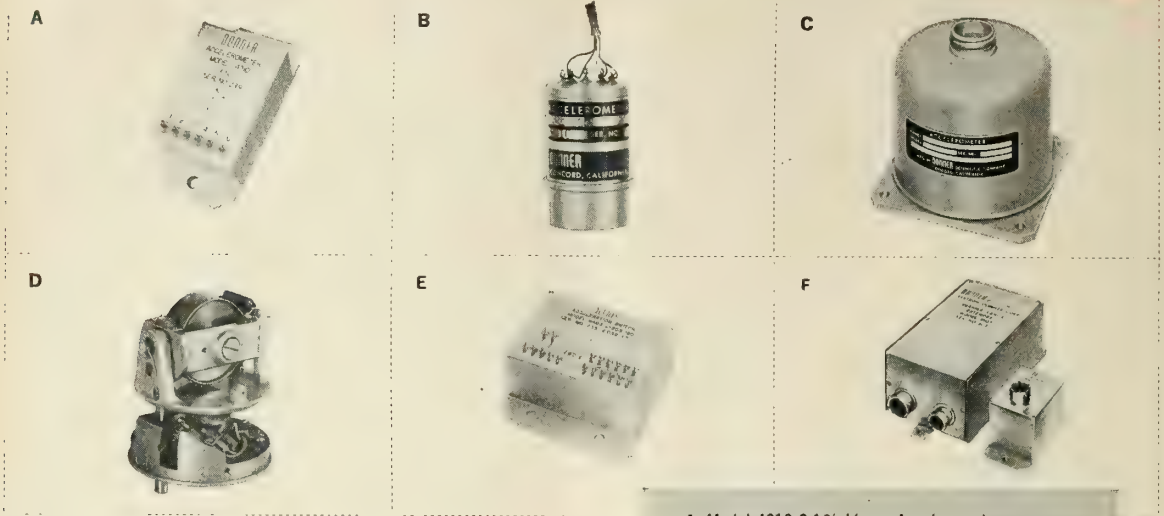
ZUNI (Navy)—CONTRACTORS: Naval Ordnance Test Station, prime; Hunter-Douglas, propulsion. DESCRIPTION: air-to-surface; weight 107 lbs.; solid propulsion; warhead, conventional; range, 5 n.mi.; unguided; STATUS: Operational; designed for use on jet fighter and attack aircraft.

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D. Model PHU Miniature Free Gyro.
E. Model 4403 Acceleration Switch.
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A Short Guide to

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Model 4310 0.1% Linear Accelerometer—This high output, high resolution transistorized accelerometer is designed for demanding measurement and control applications met in telemetry, gyro-erection, programming, and short range inertial guidance.
Key specifications: non-linearity plus hysteresis, within 0.05% deviation from best straight line; standard ranges, between ±0.05 g full range and ±30 g full range; resolution, better than 0.0002% full scale; weight, 3.5 ounces; standard output, ±7½ v dc and/or ±1.5 ma full scale; options, biased output, liquid filled units, and/or 28 v dc operation; 0 to 5 v dc output; price, standard unit, $450.

NOT PICTURED BUT SIMILAR IN APPEARANCE TO THE MODEL 4310 ARE:

Model 5310 Flexure Accelerometer, specially designed for high g applications. A flexure supported lightweight mechanism eliminates null uncertainty normally experienced with jewel bearing type accelerometers.

Model 4810 Guidance Accelerometer with high performance torque coil that improves hysteresis, non-repeatability and zero output by a factor of 10 to 1.

Model 4211 Low Cost Servo Accelerometer—A pivot and jewel pendulous accelerometer with all the features of a true servo accelerometer for a price below $400.

Model 5410 Non-pendulous Accelerometer—A high compliance, pure translational accelerometer utilizing a non-pendulous flexure suspended seismic mechanism. Features high output, high resolution and high accuracy in environments of high acceleration, shock and vibration.
Key specifications: non-linearity <0.05%; hysteresis <0.02%; resolution infinite; range ±0.5 g to ±30 g; shock, 50 g operating, 200 g survival. Physical configuration, round case.

Model PHU Miniature Free Gyro—This unit combines a low cost miniature design with a very flexible choice of made-to-order modifications. It can be adapted to a variety of applications where space limitations are critical and performance is a must. Options include manual or electrical cage and uncage, remote or integral power supply, and single or dual pickoffs. Measures only 2" in dia. by 2" long; weight 9 oz.

OTHER GYROS AVAILABLE: Models PJH Rate Gyro, PAW HIG-4 Integrating Gyro, PAU HIG-3 Integrating Gyro, and PJT Two-Axis Free Gyro.

Model 4403 Acceleration Switch—Systron-Donner acceleration switches are used to accurately determine the point of thrust termination in missile and satellite vehicles. Because of their high natural frequency, they offer excellent dynamic response.
Key specifications: ranges, 0.05 g to 100 g; unregulated power, 28 v dc ±10%; temperature range, 30° F to 150°F; output, relay closure; weight approximately 12 ounces.

Model 4106 Vernier Range Extender—The resolution of telemetered flight data can now be improved by a factor of 12 to 1 or more over standard 2% FM/FM data links. In operation, the Model 4106 provides two distinct 0-5 vdc outputs. One output generates ±1.0 g steps of measured acceleration, the other resolves the differences between steps to 0.04 g.
Key Specifications: ranges, ±0.05 g to ±35 g; input power, +28 vdc ±2 vdc; output, two 0-5 channels; weight 2.5 lbs.

OTHER SYSTEMS—

Systron-Donner specializes in the manufacture of accurate fixed and general purpose analog and digital systems designed to analyze, measure, and control inputs interlocking time, acceleration, jerk, velocity, and other dynamic inputs. Typical systems include accelerometer timer switches, airborne signal conditioner and event markers, escape and re-entry sub-systems, linear acceleration summing and storage devices, and peak reading vibration storage devices.



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Versatile Vibrating-Reed Electrometer Delivered to NASA

Applied Physics Corp. instruments will be off-the-shelf units providing new high accuracy and stability for long satellite missions

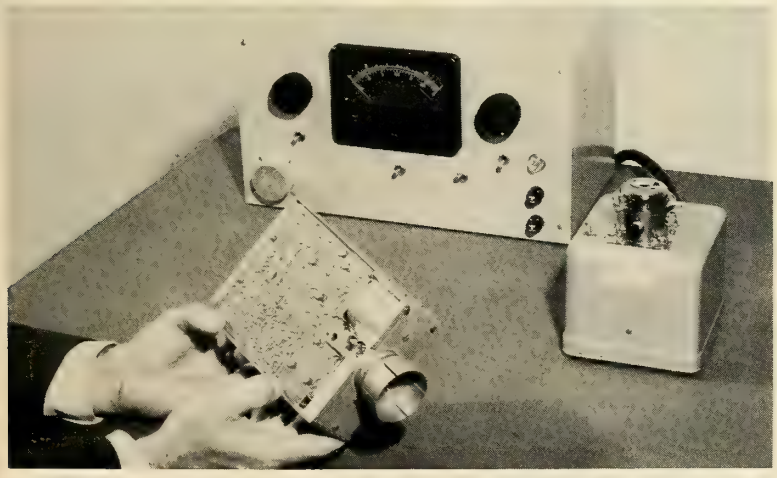
MONROVIA, CALIF.—First of a series of vibrating-reed electrometers for measuring extremely low currents, intended for off-the-shelf use in satellite experiments, has been delivered to NASA's Goddard Space Flight Center.

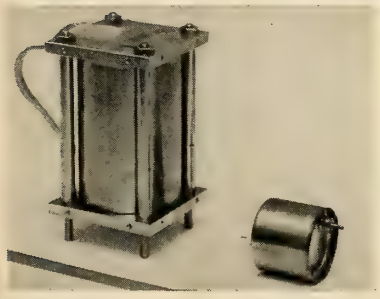
Committed to no particular flight program, the instrument is planned as a reliable device of known characteristics that can be offered to physicists for use in a variety of satellite experiments.

Five electrometers, made by Applied Physics Corporation, are to be delivered by the end of October, under a $66,000 fixed-price contract.

Harold Reed, Engineering Technician in the Aeronomy and Meteorological division at Goddard, explained that this funding was part of a program to provide instruments with high accuracy and stability over long missions.

He suggested that most of the easy experiments for satellites had been done and now more accurate measurements of the characteristics of space were required. At the same time, larger payloads were becoming available and the capacity of experiments was outrunning instrument capabilities.





TOP: New Cary Model 3710 Vibrating-Reed Electrometer designed for space-flight studies being held to compare its size with laboratory-type Model 31 Electrometer. New Model 3710 contains built-in preamplifier input unit, while Model 31 unit is separate (shown alongside main amplifier in photo). LEFT: Photo illustrates comparative sizes of Cary vibrating-reed converter unit (left) used in laboratory electrometers and new space vibrating-reed converter unit.

● **Other awards let**—Other contracts for this program to get better instrument performance in space are a $75,000 contract with Raytheon to develop improved electrometer tubes and a contract—now concluded—with Melpar for development of stable multi-megohm resistors.

Goddard probably will be putting out RFP's for a study to look at semiconductors for low-current measurements. The two areas of interest are insulated-gate field-effect transistors, and metal-oxide silicon diodes.

Likely applications for the Applied Physics vibrating-reed electrometer are in spaceborne mass spectrometers, ionization gauges, and electron-temperature probes. Proving flights in sounding rockets are likely in the spring of 1965.

● **VRE specs**—The VRE delivered to Goddard, Cary Model 3710, was developed from a Model 31 laboratory instrument. Weight was reduced from about 50 lbs. to 1,100 grams, volume cut by a factor of 30, and power consumption squeezed from 50 watts to 1 watt. Overall dimensions are 4 in. by 6 in. by 1½ in.

The instrument has a limit of detection of 10^{-17} amperes. In its present form it has a linear range of 10^{-9} to 5 x 10^{-16} ampere with one range change, using 5 x 10^{9} ohm and 10^{12} ohm input resistors.

Inherent accuracy is ± 1%.

In the laboratory, the instrument can detect a current of between 63 and

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Experimental Engineers . . .



100 electrons per second, but this would not be a practicable measurement to attempt in a satellite.

Automatic compensation for temperature changes of contact potential is incorporated.

Drift rates of about 20 microvolts in 20 minutes are being obtained, and the instrument can be run for periods of 40 minutes without rezeroing.

The d-c input signal to the instrument is converted to a-c by vibrating one plate of an input capacitor at 5 kc. Amplification, rectification, and filtering yield the output signal. Negative feedback of part of this signal produces the instrument's high stability.

Automatic range changing will be fitted to flight versions of the VRE, to minimize effect of telemetry constraints.

Areas of future interest at Goddard will be the response of the instrument to energetic particle radiation and to sterilization procedures. ■

DOD/Contractor Information System Pilot Test Begun

A plan for establishment of an engineering data retrieval system for defense contractors and Dept. of Defense components was started on a one-year pilot test Sept. 1, the Pentagon has announced.

The test will determine feasibility, cost and user acceptance of a mechanized system for interchange of engineering and technical data.

An exception will be information now being distributed by the Defense Documentation Center.

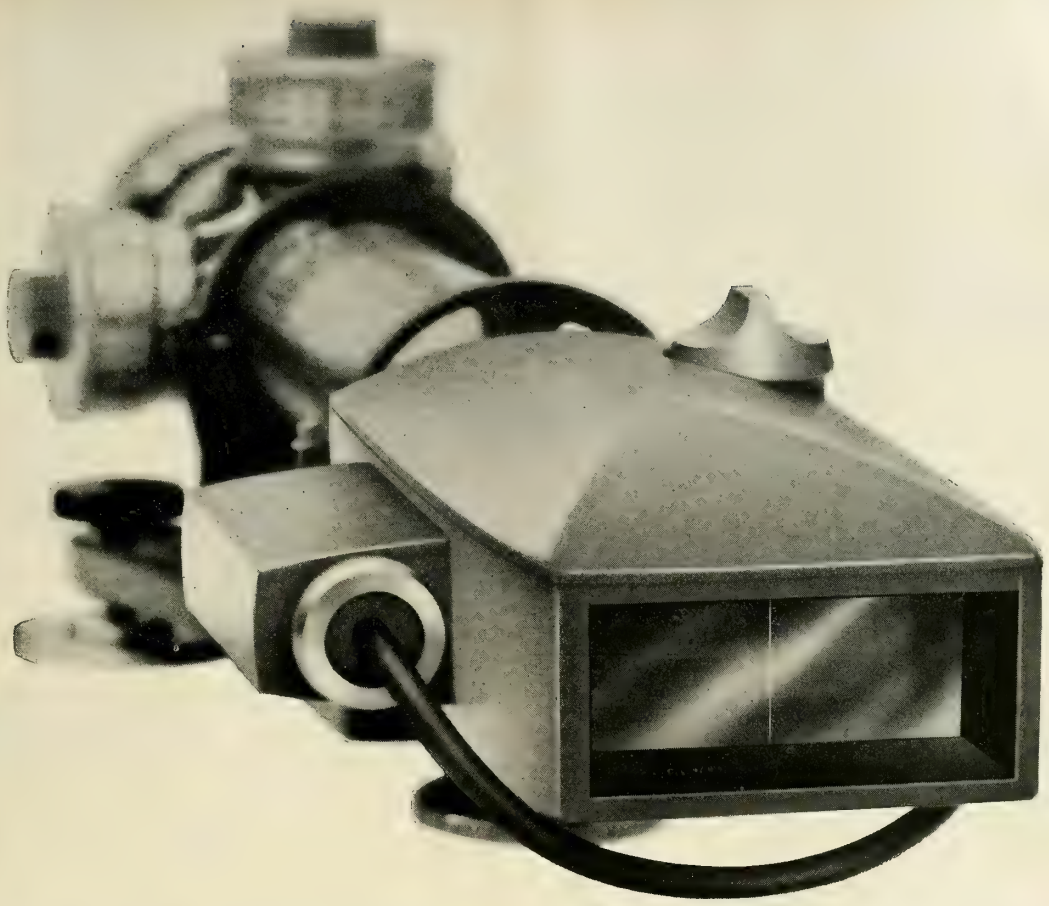
The program is a joint effort of the military services, the Defense Supply Agency of the Dept. of Defense, and selected defense contractors.

It will use the present data-retrieval engineering system file of the Army Missile Command, at Huntsville, Ala., a mechanized microfilm data file of standards, specifications and common item drawings.

A similar engineering data file will be assembled for fixed resistors in Federal Supply Class 5905, the announcement said.

These will be located at approximately 25 defense contractor facilities.

Results of the pilot test will be evaluated in August, 1965, DOD officials said.



New angle-measuring interferometer

Kollmorgen Model K-421 brings 0.02 second-of-arc sensitivity out of the laboratory into practical engineering use.

Uniquely simple! Unlike conventional interferometers, portable Model 421 Pointing Interferometer has a single optical element . . . a special Koesters double-image prism having equal internal paths. Permanent calibration is inherent. Minimum operator training is required.

How it works! The four-pound Model K-421 is designed to mount on an alignment telescope having an NAS 2.25-inch diameter barrel. Two parallel beams of light are projected at a plane mirror. Mirror rotation changes the path lengths of the reflected beams and establishes an interference fringe pattern.

Highly sensitive! Model K-421 is so calibrated that one interference fringe represents a mirror rotation of one second of arc. With the optical micrometer on the Kollmorgen K-122 alignment telescope, you can subdivide each fringe into increments as small as 0.02 second of arc. With the Model K-120 Line-of-Sight Alignment Telescope, visual interpolation to 0.1 second of arc is readily attained. Rotation angles up to 2000 seconds of arc can be measured. Measurement error does not exceed 0.1 percent of measured angle, or 0.02 second of arc, whichever is larger. Maximum working distance is 25 feet.

A versatile instrument! Other uses for this high-precision interferometer include measurement of absolute pressure, gravity level reference, sphericity, film thickness, surface parallelism, refractive index differences and homogeneity of transparent materials. It also handles many of the angle measuring tasks usually assigned to autocollimators, but with five times the sensitivity.

Informative 12-page bulletin contains complete data on Model K-421 and other new Kollmorgen optical tooling instruments: Single and Dual-Axis Autocollimators, Dual-Axis Automatic Autocollimator, Dual-Micrometer and Line-of-Sight Alignment Telescopes and all required accessories. Write today to Director of Instrument Sales for this bulletin, specifying whether you want early demonstrations.

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Camera Capsules Aid Saturn Program

Cook Electric parachute-recovered system derived from early work with missiles may lead to application in various future projects

A LITTLE-PUBLICIZED but important and highly successful subsystem of *Saturn I* is aboard *Saturn SA-7*, due to be launched from Cape Kennedy this week.

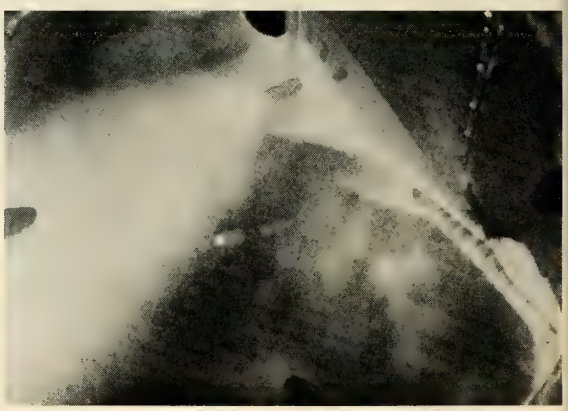
It is the recoverable camera capsule developed by Cook Electric Company, Morton Grove, Ill., for *Saturn* as an outgrowth of earlier recoverable data-acquisition capsules for Air Force missile programs. The company believes that the concept may be useful in a variety of future space projects.

Each of the last two *Saturn I's* has carried eight of the Cook camera capsules containing D. B. Milliken Co.-built 16-mm motion picture cameras. After the *SA-5* launch on Jan. 29, seven of the cameras were recovered before the search for the eighth had to be given up because of choppy seas. During the flight of *SA-6*, launched May 28, the cameras recorded—among other things—separation, coast and ignition of the second stage. Jettisoned from 300,000-ft. altitude, all eight cameras were recovered by the Air Force Air Rescue Service.

SA-7 will also carry eight capsules.

(*Continued on page 56*)









THESE PHOTOS were taken during Saturn SA-6 launch by D. B. Milliken Co.-built 16-mm cameras carried in Cook Electric camera capsules. TOP LEFT: Looking into space from an outboard camera just before stage separation. TOP RIGHT: Second-stage ullage motor ignites. BOTTOM LEFT: Second stage coasts free. BOTTOM RIGHT: Second-stage motors ignite.

REQUEST AND AUTHORIZATION FOR MILITARY PERSONNEL TDY TRAVEL
AND CIVILIAN PERSONNEL TDY AND PCS TRAVEL
(AR 30- [illegible] and JTR 1-)

1 TYPE OF TRAVEL ORDERS
☒ TDY, UCMR PROPER STA. ☐ PCS (Civilian only) ☐ CONFIRMATORY ORDERS

2 NAME OF REQUESTING OFFICE: Army Tank Automotive Center
3 TELEPHONE EXT
4 DATE: 23 June 1964

5 FIRST NAME, MIDDLE INITIAL, LAST NAME	GRADE	SERVICE NUMBER	ARMY UNIT, TRAVEL MODE, POST/OTHER THAN HOME STATION
The Goer	8-ton tactical support vehicle	19748	U. S. Army

6 ORGANIZATION AND STATION: 7th Army
7 TO PROCEED [illegible]
8 APPROXIMATE NUMBER OF DAYS
9 ITINERARY: Via Kenosha, Wisc.; St. Lawrence Seaway; Le Havre, France; Frankfurt, Germany
☐ CIPAP

10 PURPOSE OF TEMPORARY DUTY: Test and Evaluation

11 TRANSPORTATION AUTHORIZED
☐ COMMON CARRIER ☐ AIR ☐ SURFACE ☐ WATER ☐ AS DETERMINED BY TRANSPORTATION OFF (Military only)
☐ GOVERNMENT OWNED ☐ VEHICLE ☐ AIRCRAFT ☒ VESSEL
☐ PRIVATELY OWNED VEHICLE AT RATE OF _____ CENTS PER MILE ☐ TPA TMDAG
☐ REIMBURSEMENT LIMITED TO COST OF TRAVEL BY USUAL MODE OF TRANSPORTATION, INCLUDING PER DIEM (Civilian only)

12 PER DIEM AUTHORIZED (Civilian Personnel only)
☐ MAXIMUM AUTHORIZED BY CPR 7.3 ☐ OTHER (Specify)

13 TRANSPORTATION OF DEPENDENTS (Civilian Personnel)
☐ EMPLOYEE REQUESTS TRANSPORTATION OF DEPENDENTS UNDER 22 YEARS
☐ TRANSPORTATION AUTHORIZED BY GOVERNMENT ☐ AIR ☐ SURFACE ☐ WATER
☐ TRANSPORTATION AUTHORIZED BY COMMON CARRIER (Commercial Air, Rail, Water)
☐ TRANSPORTATION AUTHORIZED BY PRIVATELY-OWNED CONVEYANCE

14 SHIPMENT OF HOUSEHOLD GOODS (Civilian personnel only)
☐ EMPLOYEE HAS DEPENDENTS AND IS AUTHORIZED MOVEMENT OF HOUSEHOLD GOODS NOT IN EXCESS OF 7000 POUNDS NET WEIGHT
☐ EMPLOYEE DOES NOT HAVE DEPENDENTS AND IS AUTHORIZED MOVEMENT OF HOUSEHOLD GOODS NOT IN EXCESS OF 2500 POUNDS NET WEIGHT

15 REMARKS (Use this space for special requirements, delay, authority for issuance, names of dependents, designation as courier, superior accommodations, excess baggage, etc.)

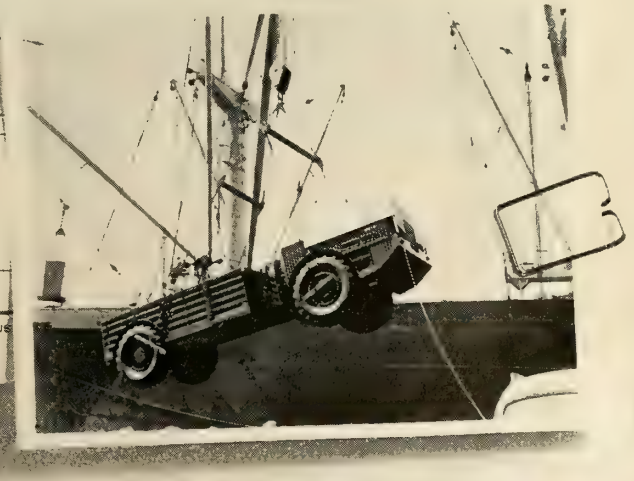
Goers are scheduled for a full-scale troop test program. These units -- designed with ATAC by Caterpillar's Defense Products Department -- will participate in full field maneuvers as well as individual test operations.

16 ADMINISTRATIVE APPROVAL
Lee F. Cirlee
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● **Early programs**—The recoverable capsule concept originated with the *Titan I* and *Minuteman* programs, in which data-recording capsules designed and manufactured by Cook were used to obtain functional and operational data on the ballistic missiles in flight.

These capsules were ejected from the missiles after accomplishing their recording function, then landed in the Atlantic Ocean by self-contained reentry and descent systems for recovery and data study. The capsules and their recovery package had a notable record of recording temperatures, pressures, and other in-flight data, protecting this data during the ejection sequence, and providing the means for recovery of the recording. They filled an important gap in situations where telemetry systems were not effective.

From this early recovery of data capsules have developed Cook recoverable camera capsules which have functioned successfully on a variety of rockets and missiles, including *Saturn, Atlas,* and *Titan II.*

Space filming and recovery has concentrated on recording pictorial events of engineering significance in the launch —stage separations, retrorocket and ullage motor firing, upper-stage ignition, fuel sloshing action and consumption rate. The sequence of images on movie film provides valuable information which might not be gleaned from single photos.

The future potential of film documentation during vehicle launch is enhanced by the fact that it is possible to store more bits of information per square inch on film than by any other method—and this is true by several orders of magnitude. Because of what can be done by adding energy via film developers, storing information on film also requires less energy than other systems. At some time in the future, film may actually be used not just to photograph sequence action but to store data—the data then being retrieved by means of recoverable capsules.

● **Parachute key**—The system of deploying parachutes at supersonic speeds was the significant breakthrough by Cook engineers that pointed the way to continuing development of recoverable data acquisition systems and their application to missile and rocket programs. It was developed by Chester F. Bilinski, program manager in the Aerospace Technology Section of Cook's Tech-Center Division.

Work on these recoverable systems dates to the earliest phases of the U.S. missile and space program. A Cook recovery system brought back the first object ever returned from space, the *Jupiter C* nose cone in 1957. Another of the company's recovery systems brought back the space monkeys Able and Baker in a full-scale *Jupiter* nose cone in 1958. The highest-speed parachutes currently in use, the Hemisflos with speeds to Mach 2.2, are based on designs developed by Cook.

To extend the ability to recover capsules at higher speeds from higher altitudes, Cook aerodynamicists now have developed Hyperflo parachutes which have been successfully wind-tunnel-tested at speeds of more than Mach 6.

Cook Tech-Center developed the recoverable camera capsule system, as used on *Saturn I,* in close coordination with NASA/Marshall's A. J. Davis, chief, Environmental Studies Unit, Astrionics Laboratory.

The system provides color motion picture monitoring of selected launch events from suitable locations on the vehicle. The capsule is ejected at a preselected time after staging and is designed to re-enter the Earth's atmosphere, from about 90-mi. altitude, in a stabilized attitude at about Mach 10.5.

After re-entry, the capsule decelernates to a terminal velocity of 90 fps to enter the water, then floats.

● **Breakdown**—The capsule consists of the instrumentation section with control unit and a recovery section.

The recovery section, packaged be-



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Test Analysis Engineers — BS or equivalent with 1-3 years experience in developmental testing desirable. Positions entail development of test logic for flight tests, integration of subsystem and system requirements into general test plans; preparation of detail plans, measurement requirements, test sequences and analysis and reporting of test results.

Launch Operations Engineers — BS or equivalent with 2-5 years experience in check-out and launch operation. Positions entail preparation of check-out plans and accomplishment of pre-launch and launch operations associated with payload including liaison and coordination with booster and Government facility; and coordination of facility and other requirements for launch operations.

Measurements — BS in ME, AE or CE with at least 3 years experience in design and calibration of multi-component strain gage balances, thrust stands, or weighing systems. Assignments will include design of wind tunnel balances, complex structural component gaging and high temperature, high vacuum strain gaging studies.

BS in ME, EE or Physics with 4 years experience in Instrumentation measurement problems. A good theoretical and practical knowledge of transducers, their specifications and application to measurement of temperature, pressure, flow, acceleration, rate, force, is required.

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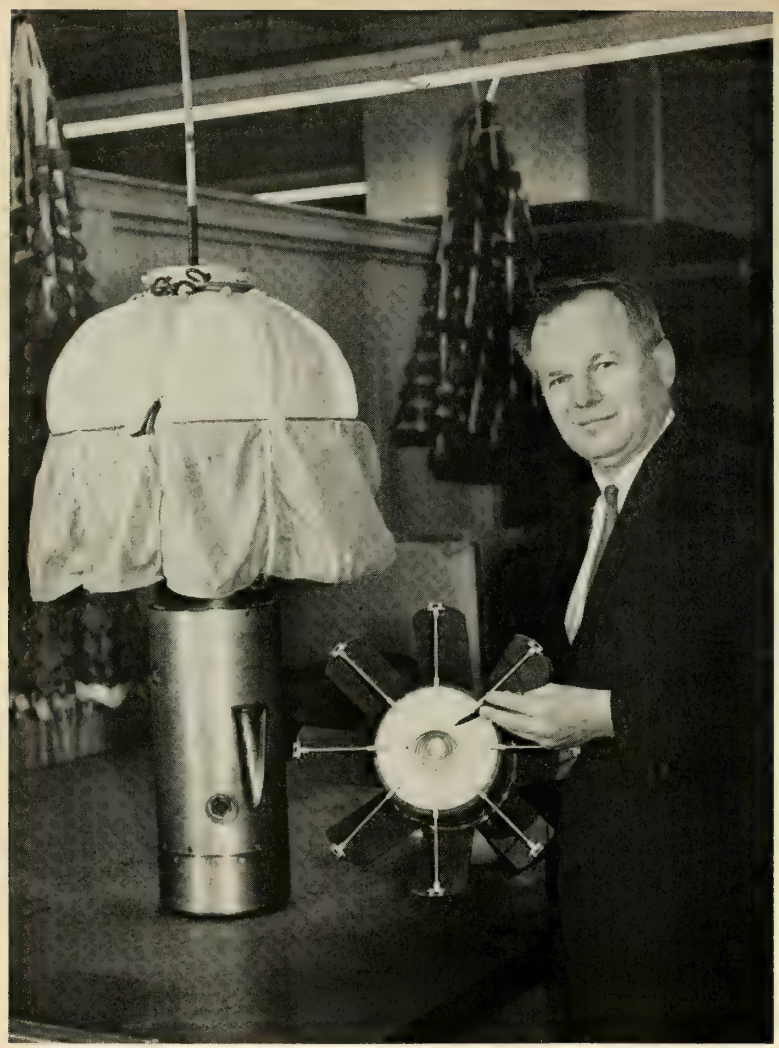
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SHOWN WITH Cook recoverable camera capsule is Chester F. Bilinski, program manager, Tech-Center Div., who developed key parachute deployment technique.

hind the instrumentation, includes eight stabilization and deceleration flaps at the top end of the capsule, 18-in.-dia. flotation and deceleration paraloon (combination parachute skirt and balloon), and recovery location aids, including radio transmitter and flashing light, radar chaff, dye marker, and shark repellent.

The instrumentation section is adaptable to various types of cameras but up to now has used the 16-mm camera made by Milliken. The camera operates on 28 volts d-c power from the space vehicle. It contains a thermostatically controlled heater and is equipped with shutter pulse generator and fiducial marking.

The camera carries 100 ft. of film, which provides 125-, 63-, or 10-sec. coverage at film speeds of 32, 64, or 400 frames per sec., respectively. The capsule is fitted with quartz viewing window and wide-angle 110-degree lens with focal length of 0.1655 and maximum F-stop opening of 1.5.

The instrumentation section control unit contains sensing components to initiate events in the recovery sequence during capsule flight—the capsule's tiny "brain" system in effect, making it function as a miniature missile. The control system has two redundant circuits, each capable of controlling and firing various recovery functions. A single on-ground shorting plug provides ground safety; a single in-flight arming plug brings battery power from the rocket to the proper switches and relays.

Components redundancy is used wherever practical in each circuit and in two instances an interchange of component switch contacts is made between circuits. This permits continued circuit operation of one circuit where a component failure has occurred, contingent on the counterpart component having operated in the other circuit.

This feature increases overall reliability of operation with little additional circuit complexity. Each circuit is identical in operation. The power for the radio transmitter and flashing light also is packaged separately in the instrumentation section and provides 6 volts for approximately 20 hours.

All of these components are assembled in an insulated instrumentation section designed to permit temperature fluctuations between —20 and 150° F. and relatively humidity of 30 to 60% at 10 psi or more pressure.

● **Saturn sequence**—Here's the way the capsules functions on *Saturn*:

During ascent of the vehicle with the capsule, the initiating aneroid actuates at 14,000 ft. and grounds a parallel combination of time delays in series with a resistor. At 40,000 ft., an arming aneroid actuates, bringing battery power to the ungrounded side of the initiating aneroid.

At 250,000 ft., the camera is started by the vehicle control system.

At 300,000 ft., the camera capsule is ejected from its mounting tube on the rocket by means of a piston-and-cam-activated finger which fits in a capsule slot and pushes out the capsule at 25 ft./sec. velocity. The camera is electrically disconnected by this action.

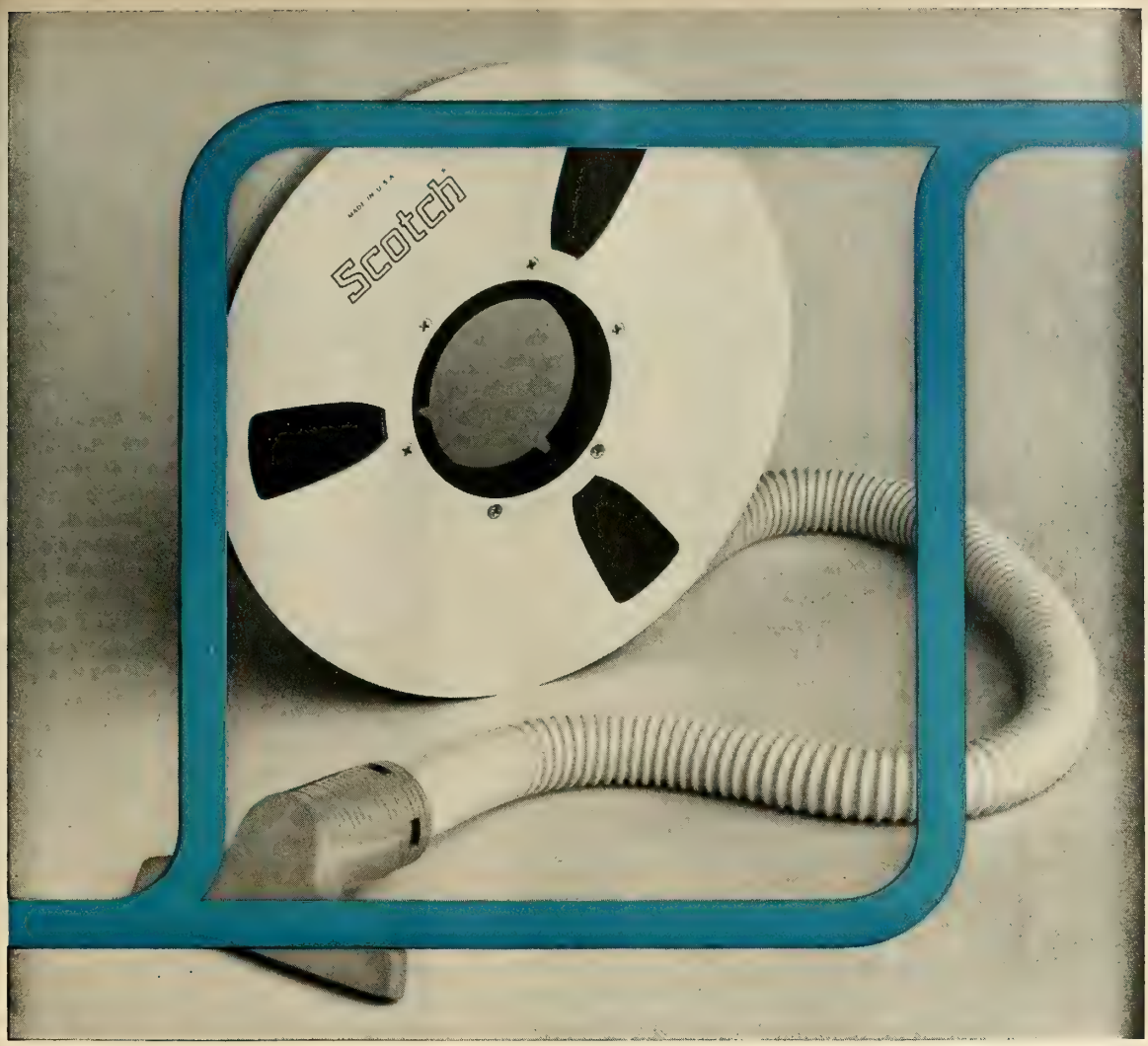
Immediately after ejection, deceleration and stabilization flaps are extended 30 degrees from the capsule body and locked in position to provide a zero angle of attack.

The capsule continues upward to 450,000 ft., then begins its descent, reentering the atmosphere at speed of about Mach 10.5. At 40,000 ft., the aneroid switches function, removing power from the arming time delay circuit. At 14,000 ft., aneroids fire explosive valve squibs which blast off the top cover and fins and inflate the paraloon by high pressure. Various time delays are started at this point, radar chaff is deployed, and antenna erection squibs are fired. Radio and light beacons are turned on.

When the capsule impacts in the ocean, it is floated by means of its paraloon. Dye marker and shark repellent are activated.

The recoverable capsules are modified for the particular environments to be faced with the various vehicles or missiles. Aboard *Saturn,* the capsules photograph and bring back films of the S-I and S-IV stage separation, retrorocket and ullage motor firing, S-IV ignition, and fuel action inside the tanks.

● **Other prospects**—The valuable application of recoverable data systems also appears to have other possibilities



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TECHNICAL TALK Bulletin No. 4 offers detailed discussion of static-caused problems in instrumentation recording, helpful information for solving them. Free. Write 3M Magnetic Products Division, Dept. MBW-94, St. Paul 19, Minn.

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in space vehicle launch. Leo Arsement, chief, Telemetry Systems Engineering Section, Astrionics Laboratory, at NASA's Marshall Space Flight Center, points out that, in the period from vehicle liftoff to 2,000 ft., a recoverable recorder capsule would allow data accumulation time to be extended beyond that presently available through the use of drag-cable hookups, thereby allowing high-frequency data such as temperature and vibration to be obtained without adding more RF telemetry links.

It also is possible that recoverable video tape recorders could be used, at the same altitude range as the camera capsules, to acquire data on the second stage, retrofire, and equipment in the rocket or missile by "taping a picture" instead of using a film camera. Such recorders could also record higher-frequency data than a normal telemetry link could transmit and could be returned from space by the same techniques as utilized with the camera capsules.

Cook's Tech-Center Division, working closely with Arsement, has developed a new recorder and capsule and has worked out a recovery system design for a recoverable recorder capsule for NASA/Marshall for use in gathering early-launch data. Such a capsule, using a recorder with precise speed control, could be ejected shortly after launch, recording data to about 2,000 ft. or more. In current planning stages, the recorder capsule would be brought back to the launch area, on land, for recovery by means of parachute system.

An interesting new approach to recoverable capsule application, this low-altitude data-acquisition and immediate land recovery at launch site bring into action recovery aspects different than those at high altitude. Cook studies show that recovery within 1,500 ft. of launch site would require a system that minimizes downrange drift. The system also must reduce the opening and landing shocks so the recorder and capsule will be reusable with only minor refurbishment.

In such a system, the parachute initially would be deployed reefed to a small portion of its inflated area. The chute would be a flat, circular ribbon canopy for low opening shock and good stability. This system would bring the capsule down within easy recovery range of the launch point even in winds up to 20 mph. Data thus would be immediately available for playback, enabling the recoverable recorder to serve as a backup and to provide additional engine operational data for flight analysis.

Aluminum honeycombed nose cap or NASA's frangible-tube energy-absorption design would be used, in addition to the chute, to absorb ground impact.

● **New recorder**—The magnetic recorder Cook has developed for this application provides for the recording of 14 channels of data in standard IRIG format. Two recording modes, direct and/or wide-band FM, are available through use of plug-in solid state circuit cards. Direct recording is used for purely a-c data signals such as vibration and acoustic noise of a broad frequency range. The FM mode is used for highly accurate recording of relatively low frequency data extending down to d-c.

The recorder capsules can be located at any convenient position on the side of the booster with each capsule carrying 80 seconds record time. Thus, four recorders could provide 56 channels of information immediately after launch without tying up any RF links—and more capsules could be utilized if even more data were desired. Because of their early ejection, the capsules would provide no weight or aerodynamic problems.

The recorded tape is housed in a rugged heat-resistant metal casing inside the top of the capsule and would be recoverable without damage, even in event of an abort which required ejection of the capsule below 1,000 ft. Delayed parachute deployment would protect the chute from possible flame damage as the vehicle passes in such situations when the information from the early-record capsules would be of utmost benefit in post-flight evaluation.

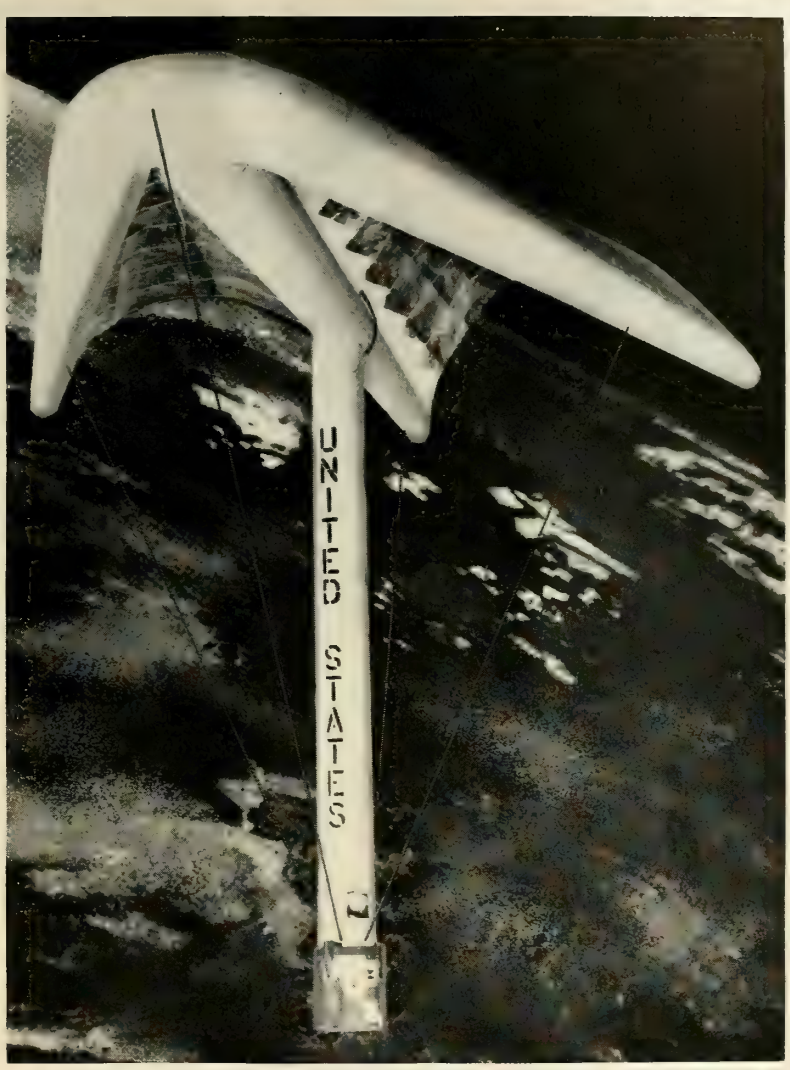
As previously indicated, two types of signal conditioning amplifiers are available for use interchangeably with the transistorized tape recorder to handle signals of various frequency ranges from either low- or high-level transducers. The recorder control is initiated upon demand from inside the rocket, upon application of primary 28-volt supply through an interface mounting connector.

Recording starts within 1 sec. after voltage application. Intermittent application of supply voltage is feasible during the full record cycle, since record time does not have to be continuous.

The recorder has a preset timer to control integrated time of record cycle and initiate ejection of the capsule from the vehicle. The recorder and timer are fed by the same voltage. The ejection thruster is self-contained and provides the force to separate the capsule from the vehicle with sufficient velocity to clear the rocket plume.

The adaptability of the capsule and recovery concepts to varied date-acquisition requirements and environmental conditions would seem to open the way to more extensive augmentation of in-flight engineering feedback as the nation's space efforts progress. ■





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To produce this vehicle, BFG engineers developed a special high temperature fabric lamination for the inflatable frame. Made of glass fiber coated with silicone resin, it is designed to withstand temperatures up to 1150°F for about 20 seconds. Membranes or "sails" are attached to the inflated tubes.

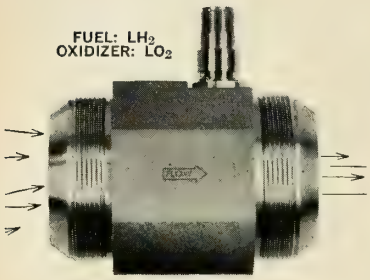
The paraglider was produced for the National Aeronautics and Space Administration by B.F.Goodrich in conjunction with Space-General Corporation, the prime contractor. A Space-General Aerobee 150 rocket furnishes propulsion. The project is managed by NASA Langley Research Center, Hampton, Va., under the over-all direction of NASA's Office of Advanced Research and Technology.

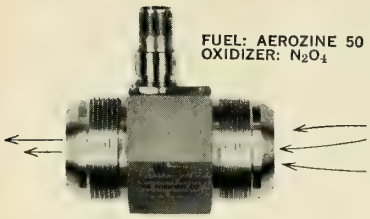
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Both Upcoming Mariners May Pass Behind Mars

by Rex Pay

STANFORD, CALIF.—At least one, and possibly both, of the *Mariner* Mars spacecraft to be launched this fall will follow a trajectory that passes behind Mars.

Changes in the 2,300-mc telemetry signal as the planet occults the probe are expected to indicate the surface pressure of the Martian atmosphere to an accuracy of 5-10%.

Jet Propulsion Laboratory has been reluctant to use a trajectory of this type because of the loss of contact with the probe as it passes behind Mars. If anything happened to *Mariner* during this time, such as loss of stability or thermal control, the Deep Space Instrumentation Facility would be unaware of the event and could take no steps to remedy it until the probe re-appeared.

Now this penalty is being accepted as a result of recent astronomical measurements that revise estimates of Martian surface pressures by an order of magnitude—to a value between 10 and 100 millibars. Confirmation of this figure is extremely significant for the Mars lander that may be launched in 1971.

Without accurate knowledge of the surface pressure, design of the probe would have to be for worst case, and the payload cut by a factor of 10. If the pressure were at the lower limit, parachutes probably could not be used to retard descent and a retro rocket system would be needed.

● **New look-angle**—The change in trajectory has led to a slight alteration in the look-angle of the television system (M/R, Aug. 3, p. 38). However, the occultation will not delay the transmission of the television pictures since playback from the recorder is not scheduled to take place until 8 hours after encounter with the planet.

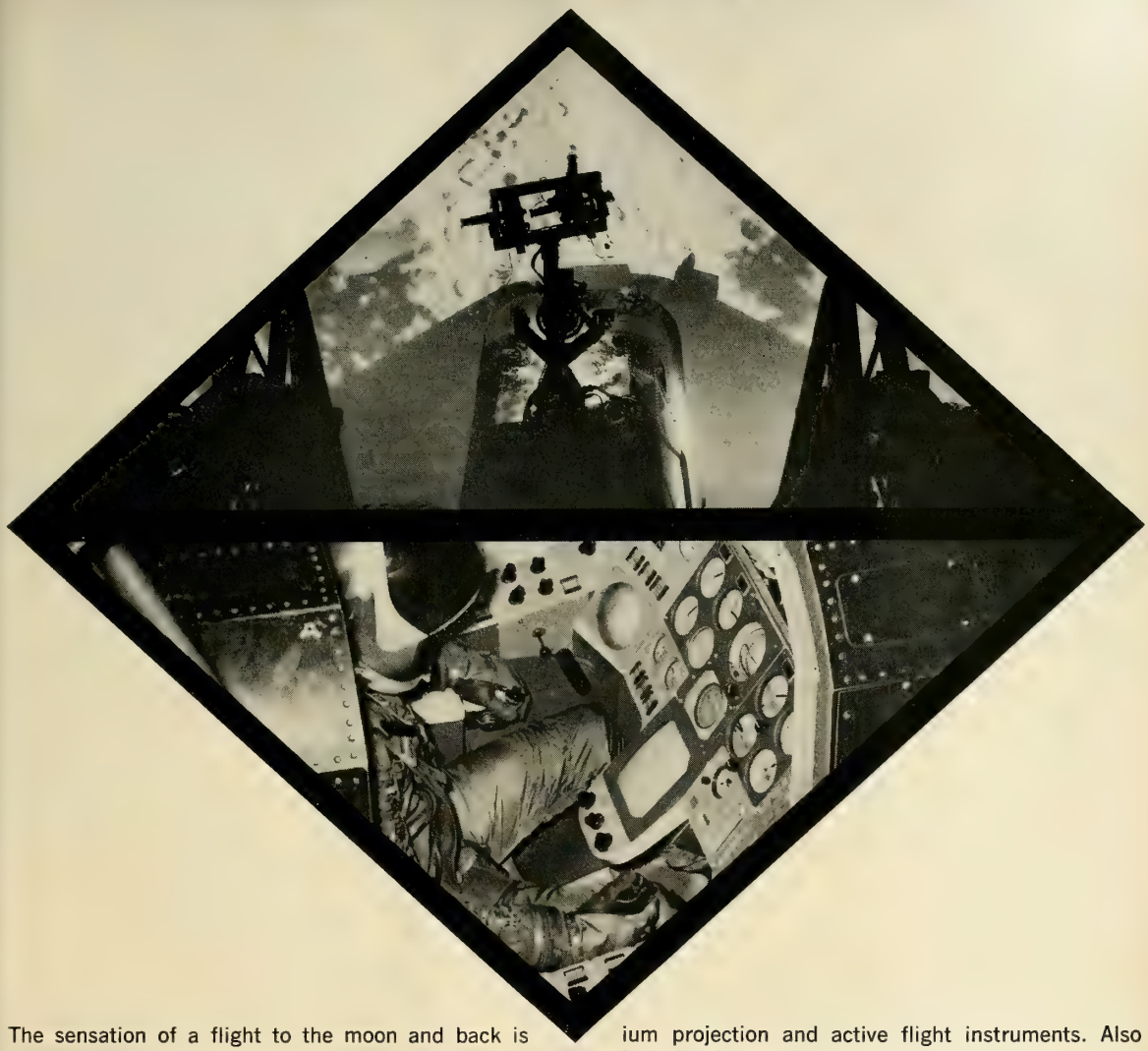
Apart from its drawbacks, the occultation measurement is in several respects an ideal experiment. It requires no added weight, power space or information capacity in the spacecraft because it uses the existing telemetry signal. Several different frequency and amplitude measurements will give independent information about pressure-

Space Library

LEFT: Two North American Aviation engineers have invented a portable data storage and retrieval assembly capable of displaying any document in a 12,000-page library stored within it on microfilm. RIGHT: Engineer uses early model of assembly inside mockup of Command Module.



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temperature ratios and temperature-molecular mass ratios. Combining this with other information on temperature and probable constituents will help determine actual constituents, pressure, temperature and density.

As the spacecraft passes close to and behind the planet, a number of changes is expected in the radio signal. Some will be due to refraction of the signal as it passes through the Martian ionosphere and atmosphere. Others will be due to diffraction of the signal by the edge of the planet as the probe is occulted.

The possibility of studying planetary atmospheres in this way was suggested by a group at Stanford University about two years ago. Interpretation of the forthcoming *Mariner* tests will be shared between a group at JPL and another at Stanford University. The experiment was described during an annual government-sponsored conference at the Stanford Electronics Laboratories here.

• **Measuring technique**—The group at JPL under A.J. Kliore will measure the Doppler frequency impressed on the telemetry signal as a result of atmospheric perturbations. A transponder technique will be used. A signal stable to one part in 10^{11} is transmitted 150 million miles to the spacecraft, where it is multiplied by a constant factor and retransmitted back to Earth. There it will be measured to an accuracy of about 0.1 cps. The main Doppler frequency change will be of the order of 30,000 cps, due to spacecraft velocity. Superimposed on this will be a few cycles per second change due to atmospheric effects at Mars.

Because the exact trajectory will not be known in advance, the two Doppler components cannot be separated immediately. In fact, the trajectory has to be accurately computed from the Doppler signal before and after the period of encounter, and the actual trajectory during encounter must be found by interpretation between these known paths. Then the expected Doppler record is computed and subtracted from that observed to yield the Doppler shift due to the atmosphere.

JPL estimates that the surface pressure can be measured to 5% accuracy if the pressure is near 25 mb and to 10% if it is near 10 mb.

The Stanford University group, under Professor Von R. Eshleman, is concerned with interpreting amplitude changes in the signal. The amplitude of the signal will be reduced because of dispersion of the transmitted rays in the atmosphere. Also, the radio occultation will take place after the geometrical occultation.

Both of these effects will indicate the refractivity, and therefore the density of the Martian atmosphere. However, the time of occultation is more likely to give an improved figure for the diameter of Mars rather than an indication of its surface pressure.

• **Fresnel diffraction**—Von Eshleman expects that the most sensitive measure of the refractivity of the atmosphere near the surface will come from the Fresnel diffraction pattern as the probe is occulted. The planet's disc will act as a knife edge that will give a series of fluctuations in amplitude. Presence of an atmosphere will stretch out the period of the fluctuations compared with that obtained in free space.

The Fresnel stretch that occurs will give a measure of the near-surface conditions. In addition, the loss of signal strength (about —8db) and its rate of change with time will give independent information about surface density and scale height.

Although the planet limb is not a knife edge and has curvature in two dimensions as well as surface roughness, "we believe this will not seriously degrade our ability to measure the atmospheric perturbation of the signal," said Eshleman.

He pointed out that radio stars occulted by the Moon give this pattern. This is a worse problem experimentally, because a wide-band noise source is involved and some of the higher order effects are washed out.

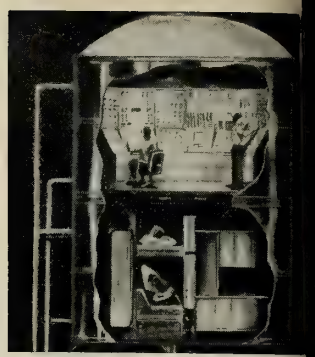
"We do not know the scale of roughness on Mars," he said, "but successful measurements on something similar (the Moon) give us confidence in the technique."

Occultation of radio sources by the Moon is currently one of the most important things in radio astronomy as it indicates whether a source is located at a point (a star) or over a wide area, with much higher resolution than an interferometer or high gain antenna.

• **Main uncertainty**—Recent theories of the formation of the Martian ionosphere based on the new low pressure values indicate a higher ionospheric density and so more-measurable effects on radio signals. The principal uncertainty in the 2,300-mc occultation experiment is in fact the possible effect of a dense ionosphere. A dense ionosphere or sharp density gradients could mask the atmospheric effect.

Von Eshleman feels that the density increase will not be too great and that the *Mariner* occulation experiment will give a relatively good indication of the refractivity profile of both the Martian ionosphere and the Martian atmosphere.

Better separation of the ionospheric and atmospheric effects would be obtained by the use of an additional transmitted frequency in the VHF region. ■



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Fixed TV on Voyager Could Provide Lander Accuracy of 100 Miles

LOS ANGELES—A fixed television camera on the *Voyager* spacecraft should improve trajectory determinations near Mars by nearly an order of magnitude, according to a paper read here at the Astrodynamics, Guidance and Control Conference.

This could allow a lander to be placed within 100 miles of certain specified areas on the planet.

Co-sponsored by the AIAA and the Institute of Navigation, the three-day conference included sessions on powered-flight guidance equations, space trajectories, and optimization. Absent were papers relating to the *Apollo* program (presented at the Wescon meeting) and to the Air Force Standardized Space Guidance and Navigation System.

Problems of interplanetary navigation received considerable attention. *Voyager* studies, partly funded by NASA Headquarters, were described by F. B. Woestemeyer, Manager Inertial and Optical Sensors Engineering, General Electric Spacecraft Department.

These studies envisage two landing vehicles carried to within 150,000 miles of the planet by an orbiter. This then places the landers on separate trajectories, for landings at two specified points. The orbiter continues on to the point of injection into orbit. At separation, the landers are on a trajectory that will pass Mars at an altitude of 1,000 miles in a plane inclined 55 degrees to the Mars equator.

Landing sites selected for the study were Pandorae Fretum (latitude 23°S, longitude 310°) and Syrtis Major (latitude 7°N, longitude 285°).

The landers are separated sequentially. The orbiter assumes the proper attitude so that a fixed impulse rocket on the first lander will place it on the desired trajectory. The lander is separated, spun up, and given a low velocity. After a time interval, the lander rocket fires and gives it the impact trajectory. Then the second lander follows the same sequence.

● **Cause of landing errors**—Main landing errors occur due to uncertainty of velocity increment imparted, errors in orienting the lander at separation, and initial navigation errors. Atmospheric density has little effect on accuracy; but low density calls for shallow entry angles, which increase down-range dispersion.

Woestemeyer concluded that an in-plane landing at an entry angle of 35-40 degrees could achieve a footprint of 100 n. mi. if orientation errors at separation are less than 3 degrees.

Woestemeyer emphasized the importance of having accurate knowledge of *Voyager's* flight path as it approached Mars. He said that the GE study suggested that the Deep Space Instrumentation Facility could not estimate the spacecraft's trajectory accurately enough from the usual Doppler measurements. Information from the spacecraft itself about its position relative to the planet would be needed. Otherwise errors would appear due to un-

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certainty of the value of the Astronomical Unit, gas leaks, uncertainties about the amount of solar radiation pressure, and uncertainties in planet ephemeris.

● **Altitude measurement**—Studying a Type II 260-day trajectory starting January 20, 1969, GE found that an uncertainty of 917 miles in altitude could result, whereas an altitude measurement accurate to within 100 n. mi. was needed to inject *Voyager* into the desired planetary orbit.

Line-of-sight readings of the planet were studied as a means of improving the accuracy of the altitude figure. Theory showed that an accuracy of ± 100 n. miles could be achieved at a range of 150,000 miles from the planet, if the sensor used was accurate to ± 1.0 milliradians.

Various sensors were studied—onboard radar, bi-static radar, line-of-sight rate from a planet tracker, and line-of-sight data. This last could be obtained in a number of ways. That proposed for *Voyager* was to take a television picture of Mars against a star background, for transmission back to Earth.

A 15 degree x 15 degree camera field of view was selected. Star maps showed that sixth magnitude stars could nearly always be found in such a field. In many regions of interest for planetary approach there are several stars of fourth magnitude or brighter. With a Sun-Canopus referenced vehicle the camera can be centered on the planet at two million miles. It can then keep it in view up to the minimum distance needed (100,000 miles). Camera orientation depends on launch date and would have to be updated at intervals of 5 to 7 days if a launch hold took place.

Once this adjustment has been made before launch no scanning or tracking of the planet is needed by any part of the spacecraft. The television system only has to be turned on—an advantage over systems that need a series of commands, acquisition and identification of planet and stars, and telemetry of angle data. The camera can also verify midcourse maneuver, lander separation, and orbit injection.

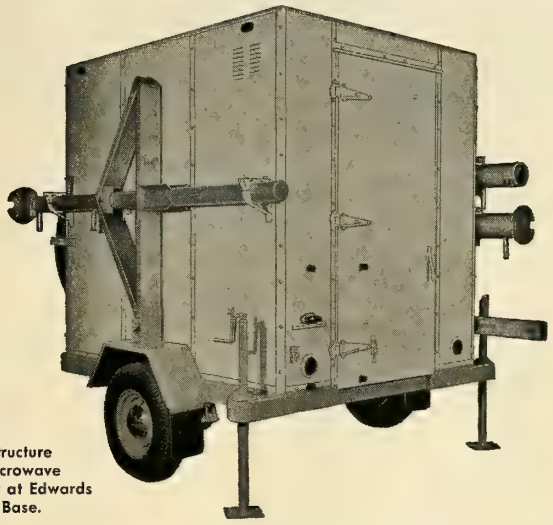
● **TV selected**—GE selected a 1,000-line image-orthicon television chain equipped with a 114-mm lens. A digital scan was chosen, consistent with that used for the onboard scientific cameras for studying the planet. Because the scene being viewed has no gray scale, the planet image can be over exposed. This means that the internal voltages in the image orthicon can be chosen to greatly extend its normal brightness range. Tests showed that stars fainter than fifth magnitude could be seen by this means, without losing sharpness in the planet image.

The same technique could not be used on a Venus spacecraft, because of its brightness. A more complex system would be needed for this mission.

The 1,000-line frame, with equivalent resolution along each line gives a resolution element representing a 0.015 degree x 0.015 degree angular area. Beam pulling will make a star appear three lines wide. However, if the star is assumed to be at the geometric center of the image, read-out error amounts to ±0.0075 degree. For the planet, the error is likely to be ±0.0023 degree, says Woestemeyer. By use of a reticule grid and knowledge of star fields, the angular position of the planet relative to the stars will be readable to ±0.029 degree or about ±0.5 milliradian.

This is well within the accuracy required.

The *Voyager* concept studied envisaged a vehicle capable of transmitting data at a high rate, to serve multiple onboard planet survey cameras. Raw video transmission from the navigation camera calls for 14,000 bits per frame. Presence of a grid would increase this. However, data compression techniques promise to reduce a requirement for about one million bits per frame to 25,000 bits per frame, for 12 stars and the planet at close range. ■

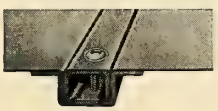


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missiles & rockets 4

BEYOND APOLLO—THE U.S. SPACE PROGRAM

MISSILES AND ROCKETS will publish its fourth annual NASA issue November 30, 1964. Now accepted as the authoritative publication on the nation's space agency, will examine the National Aeronautics and Space Administration's current and future projects, people and facilities—plus NASA fiscal 1966 budget planning now being considered by the administration.

PUBLICATION DATE
NOVEMBER 30, 1964

ADVERTISING CLOSES
NOVEMBER 16, 1964

With major procurement for the Apollo manned lunar landing program now behind it, NASA is deep in the planning of new projects to expand man's knowledge in space. Special emphasis is placed in this issue on the U. S. Space Program—BEYOND APOLLO—with detailed descriptions of post-Apollo missions:

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Burroughs Gets Gemini And Agena Guidance Job

New computer program introduced at Cape will enable simultaneous countdowns for the two launching systems

by Chris Butler

CAPE KENNEDY—The role of guiding the *Gemini* spacecraft and its *Agena* target into orbits capable of achieving rendezvous has been assigned by NASA and the Air Force Systems Command to the Burroughs Corp. ground-based guidance computer and crews here.

The Burroughs equipment and General Electric/Burroughs *Atlas* guidance team has directed control of 257 missile flights without a single computer delay or failure since winning the first *Atlas* radio command guidance contract in 1955. These include the four *Mercury* orbital flights.

● **New touches**—A new computer program, called the Universal Ground Test, was developed by Burroughs engineers to permit the Mod III Ground Guidance Computer to conduct simultaneous countdowns on the *Atlas-Agena* and *Titan II-Gemini* systems. It marks the first time such a program has been used here.

Two new arrays of Burroughs-developed equipment have been added to the computer to provide the data required for the *Gemini* program. These are the Data Exchange Unit (DEU) and the Flight Monitor Recording Console.

The DEU will accept data from NASA's tracking network concerning the target vehicle's orbital plane until T-minus 3 minutes to permit final computation of the *Titan II-Gemini* launch azimuth and trajectory to effect the rendezvous.

The DEU will be used to orient the *Gemini* spacecraft inertial guidance system before and during the launch phase to provide reference data for use during rendezvous. This information also will permit the on-board spacecraft guidance system to assume control of the *Titan II* first and second stages if the primary guidance system should fail during powered flight.

Guidance data also will be transmitted to Mission Control Centers here and in Houston to provide data for decisions concerning the astronauts' safety. DEU-transmitted data at the end of powered flight will be used by Goddard Space Flight Center, Greenbelt, Md., to predict the number of orbits the spacecraft may attain.

The Flight Monitor Recording Console will monitor 26 key performance characteristics of the guidance computer and launch vehicle telemetered back during the launch. The information will include such things as engine deflection, pitch and yaw, and the status of flight controls. If any malfunctions should materialize, Mission Control Center will be alerted so corrective or abort action can be taken.

Before the first manned *Gemini* flight takes place, the Burroughs guidance computing system with the additions will be tied in to the NASA Mission Simulator here to train *Gemini* astronauts and support personnel.

All the equipment is now in place here and interface tests are being run with the Integrated Mission Control Center in Houston, Tex.

None of the additions or modifications will interfere with continued use of the Mod III Computer System to support the *Ranger, Mariner, EGO, OAO, Atlas* Weapons System, *Fire, ABRES* and Air Force 638 programs in addition to handling the *Gemini* and *Gemini* target vehicle launches. ■

Ranger Shows No Changes Needed In Surveyor Design

But JPL project manager stresses that crater ray areas will have to be avoided

PASADENA, CALIF.—*Ranger VII* picture information "tends to remove a little of the mental anguish caused by our uncertainties about the lunar surface.

"It does not make our job any easier, but it also does not call for redesign of the spacecraft," said W. E. Giberson, *Surveyor* project manager at Jet Propulsion Laboratory, in an interview with MISSILES AND ROCKETS.

He emphasized that the *Ranger* pictures showed that *Surveyor* would have to keep away from crater ray areas. The density of secondary craters makes an automatic landing hazardous there.

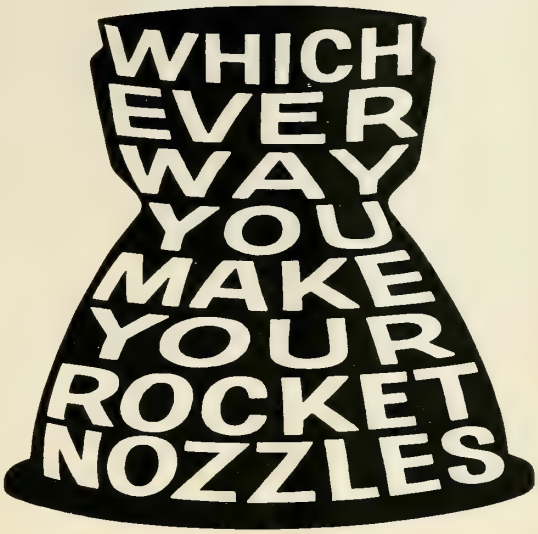
Giberson said the landing site for the first *Surveyors,* the Sea of Storms, contained a very dangerous region in the northeast, because of secondaries from the crater Kepler. However, the southwest of the sea looked smooth and probably would be a good landing site.

Giberson would like the next *Ranger* mission to photograph a part of the *Surveyor* landing area that was free of rays, to confirm that it is indeed smoother than the area photographed by *Ranger VII.*

Later *Surveyor* missions, not restricted to normal incidence landing from a direct-ascent trajectory, will have a much wider choice of landing areas.

Giberson suggested that many of the craters that appear as shadows in the final *Ranger* pictures might have side slopes of less than 23°, the Sun angle at the time they were photographed. He said some of the slopes might be as low as 10°. This coupled with the fact that *Surveyor* had landed successfully on slopes greater than its specified 15° made a successful landing in such an area more probable than it appeared on first sight. However, he did not care to put a figure on the probability of success.

• **Special problems**—The difficulty of the *Surveyor* mission and the likelihood of failures were emphasized by Giberson. He pointed out that a system like the *Atlas-Agena* was extensively tested in trial launches that were relatively close to the analysis team. *Surveyor,* on the other hand, had to carry out similar operations in reverse—ignition of main retro engine, stage separation, vernier engine operation—but in a lunar environment some 240,000 mi. away from its designers.



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"You do the best you can on Earth to test the spacecraft," he said, "but there is nothing like a flight to validate your design." For this reason the first four *Surveyor* flights to the Moon are engineering test flights, and failures are to be expected. Giberson said he would be very happy if one of the four flights landed and survived.

"There were failures on *Ranger*," he said, "but that was a tough damn mission. *Surveyor* is a tougher mission, and we are going to have failures."

● **Flight plans**—At present, seven *Surveyor* missions are authorized. They are expected to cost $250 million. After the four engineering test flights, three vehicles with scientific payloads will be launched (M/R, July 6, p. 27).

The engineering missions will carry a downward-looking television camera that will show the area of the Moon that *Surveyor* is heading for. One high-performance television camera will also be carried, to assist in survival assessment and to take a quick look at lunar topography. In the scientific missions, two high-performance cameras will provide binocular stereoscopic viewing, and extensive topographical mapping.

Giberson said that the first of the engineering flights would take place in the second half of 1965, probably after September. This would be in spite of the fact that October through February are poor launch months for direct-ascent trajectories (because there is little or no post-landing sunlight and the early *Surveyors* will not survive the lunar night). However, an engineering test flight calls only for a successful landing and indication of survival of impact.

Giberson confirmed that although there was a time when *Centaur* was holding up *Surveyor* development, this was no longer true. "It would be absolutely unfair of me to say at this time who's holding whom up," he said. "We both are experiencing some slippages because of technical problems and an expanding ground-test program to look at problems we did not see a year ago. We are both intensifying our ground-test work."

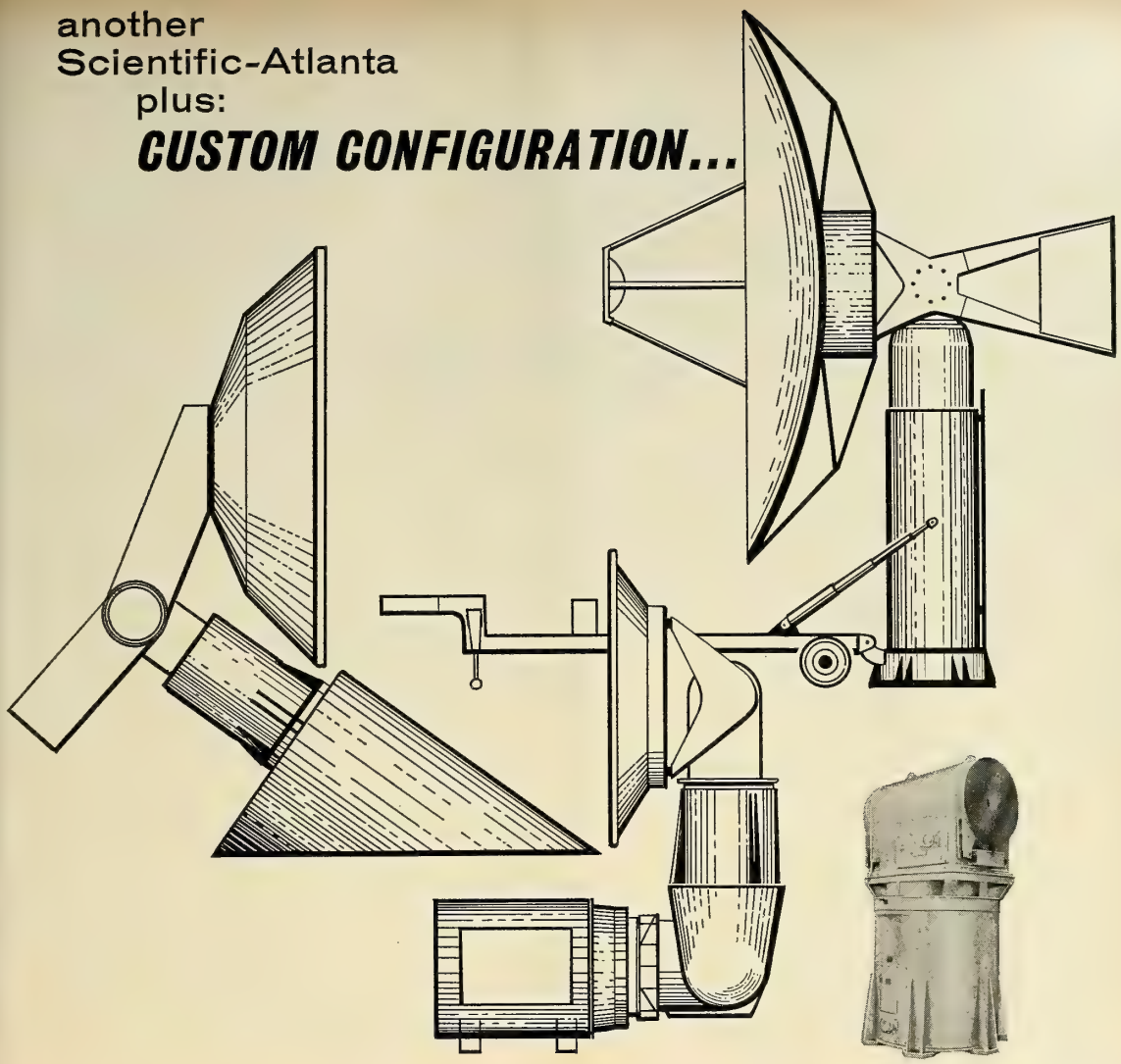
● **Changes**—Specific problems met in the *Surveyor* program have included difficulties with the three vernier motors, which control the final phases of descent after separation of the main retrorocket.

"This is one of the real critical components," said Giberson, "and we got into trouble with the design by RMD (Reaction Motors Division, Thiokol). "By coming up with some fixes, the RMD motor looks satisfactory now. In the last two months, RMD has made some very significant progress, and I'm feeling a lot better about the situation."

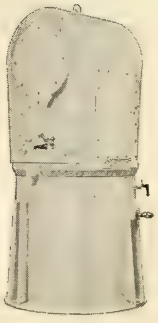
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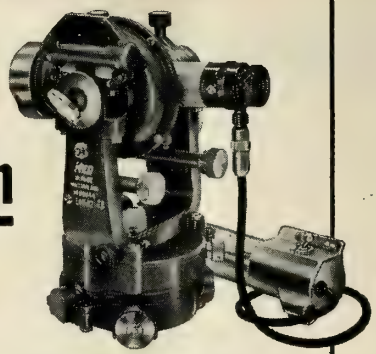
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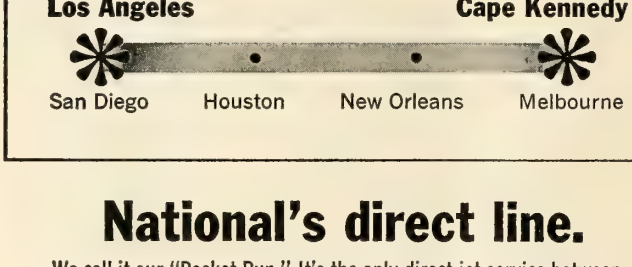
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changed to accept reduced vernier engine performance. However, the change has not been as extensive as would have been required if an alternative engine developed for JPL by TRW Space Technology Laboratories had been substituted. Although this has a very much wider throttling range than the RMD engine, which is capable of 3.5:1, it requires a different control system.

Tests of the improved descent system will be carried out at White Sands Missile Range towards the end of this month or early in September. These tests represent a recycling back to an earlier series, with a number of modifications incorporated in the system. Giberson pointed out that all sorts of problems had appeared when tests reached the system level, and he emphasized that every one would be thoroughly checked out before a lunar mission was attempted.

At one time the mast carrying the solar panel and planar directional antenna had to be lengthened to make room for a lunar rock drill. Then the drill was removed from the payload and the mast shortened. This called for an antenna design adjustment to give better center of gravity control. In early vibration tests the mast broke and had to be stiffened. This added weight which had to be compensated for in another part of the spacecraft.

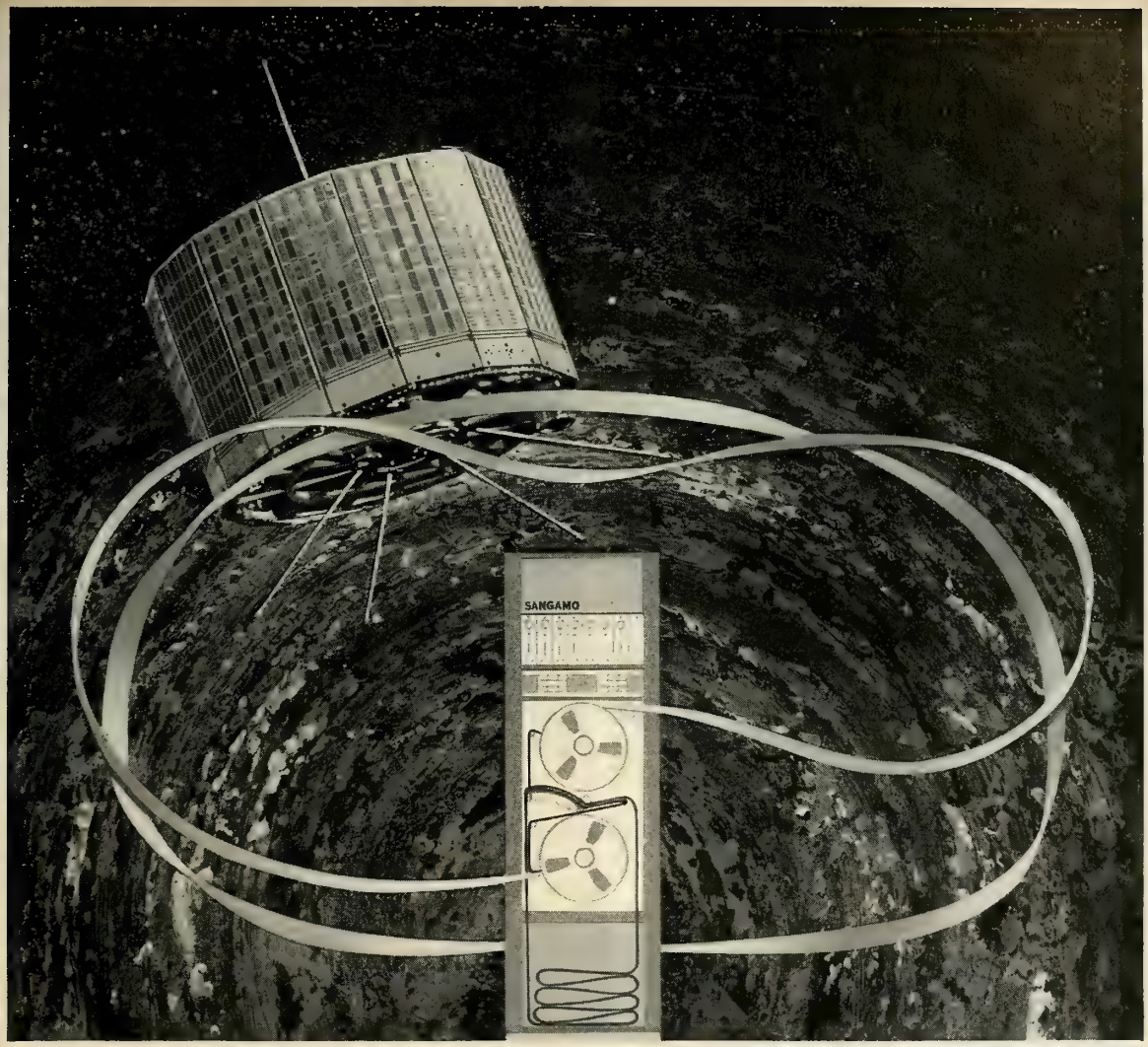
To accommodate changes of center of gravity caused by strapping on different instrument payloads, adjustable counterbalance weights are now carried on the spacecraft legs.

Thermal design of the spacecraft has also been a severe problem, not the least part of which has been in getting good simulation of solar radiation. This calls for a collimated beam over the entire spacecraft (about 13 to 14 ft across). Lack of an accurate parallel beam across this diameter leads to variations in results.

Thermal design is a problem in vehicles such as *Mariner* or *Ranger*, which travel through space at a relatively constant angle to the *Sun*. But for spacecraft on the Moon there are additional complications: the Sun angle is constantly changing and the spacecraft is sitting on a hot surface. Also, if the spacecraft should land in the shadow of a rock, it will be plunged into the extreme cold of lunar night.

"This whole thermal control problem is a major concern," said Giberson. "It is very difficult to get these conditions on Earth."

This, again, is an aspect of spacecraft design that ultimately has to be checked out on an engineering flight. "There are just as many reasons for having test flights of spacecraft as for launch vehicles," concluded Giberson.



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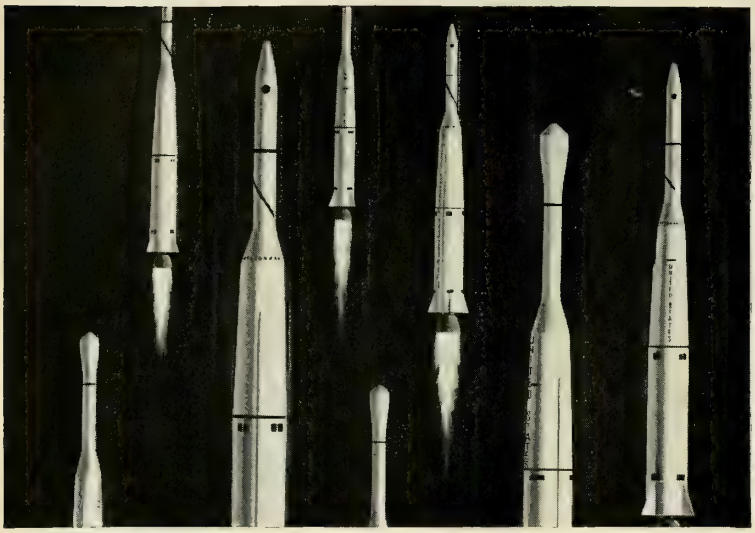
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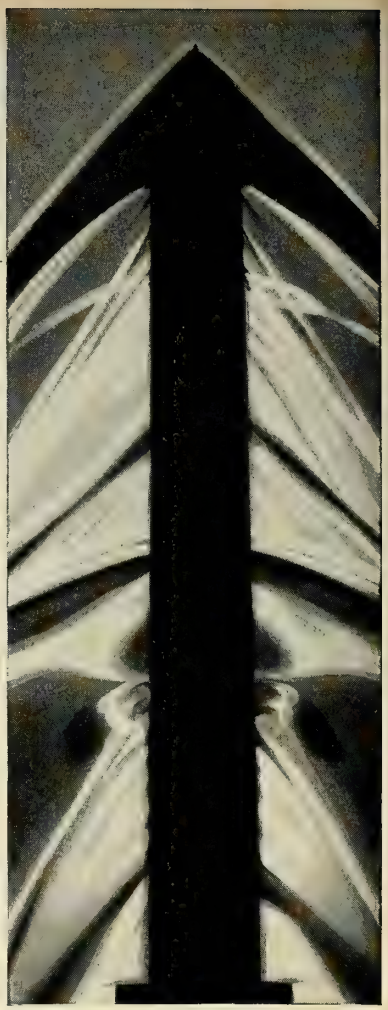
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PACKAGING THE EARTH'S ENVIRONMENT for delivery anywhere in the solar system is the aim of Douglas biotechnology research. Means are being developed to provide spacemen with air where there isn't any . . . comfort where the temperature ranges from the cold of near zero to a re-entry heat of thousands of degrees . . . protection against gravity extremes from none at all to many times what people are subjected to on earth . . . and many other equally important factors relating to man's survival in space.



SPACECRAFT SHAPES that can race through earth's atmosphere in seconds without deteriorating from the intense heat and shear effects are model-tested in the Douglas Aerophysics Laboratory. This Douglas-owned, 10-million-dollar facility includes wind tunnels with speeds up to 12 times that of sound, a hypervelocity impulse tunnel, and a ballistics range that can test models at speeds up to more than 23,000 miles per hour.

DOUGLAS

MISSILE & SPACE SYSTEMS DIVISION

Mergers and Acquisitions

Litton Industries, Inc., Beverly Hills, Calif., has acquired the assets of Mellonics Systems Development, Inc., Sunnyvale, Calif. Mellonics is involved in the design and implementation of command and control and data processing systems. It will be operated as a division of Litton's Systems Group and will continue under present management. . . . *Aeroquip Corp., Jackson, Mich., has purchased the Omniseal line of elastomer seals from Reid Manufacturing Co., Long Beach, Calif. The product is used for exotic fluid applications in the missile/space industry. Aeroquip plans to integrate the line into its Aircraft Div. in Burbank, Calif.* . . . American Electronic Laboratories, Inc., Colmar, Pa., has acquired the Davers Corp., specialist in advanced infrared detection devices and components. Davers is located in Horsham, Pa. . . . *L&R Manufacturing Co., Kearny, N.J., has purchased the Master Specialty Products Manufacturing Co., producers of aluminum shelving and chemical specialty products. The Newark, N.J., firm will be relocated in Kearny and operated as the Master Specialty Products Div. of L&R., manufacturer of ultrasonic and mechanical cleaners for precision parts.* . . . UGC Instruments, Inc., Shreveport, La., has purchased Benson-Lehner Corp., Van Nuys, Calif., manufacturer of data reduction and graphic display equipment. UGC Instruments, a subsidiary of United Gas Corp., manufactures automatic oscillograph readers and adding machine/magnetic tape equipment.

New Activities

Mohawk Data Sciences Corp., an electronic data processing firm, has been formed in New York by eight former executives of Sperry Rand Corp.'s Univac Div. V. E. Johnson, president of the new company, announced that Mohawk will "manufacture devices and provide services for management of information through electronics." The company's founders all resigned from Univac within the past few weeks, saying they were "contemplating a business venture." . . . *Philco Corp.'s Aeronutronic Div. is establishing a field station at the Army's Aberdeen Proving Grounds, Aberdeen, Md., for support tests of the Shillelagh guided missile. Leon C. Hummell has been appointed field station manager. Aeronutronic is prime contractor on the Shillelagh.* . . . Franklin Systems, Inc., West Palm Beach, Fla., has changed its name to Franklin GNO Corp. and announced plans to devote its activities solely to scientific and engineering analysis and development work. The firm was previously an instrument and electronic systems manufacturer, but now is curtailing all hardware product lines. Its primary technology is in the field of atomic energy applications and nuclear methods of measurement and control. . . . *Kaiser Industries Corp., Oakland, Calif., is consolidating the domestic and international operations of Kaiser Engineers into one division. L. H. Oppenheim will head the recombined operation.* . . . Volumetrics, Inglewood, Calif., has announced the addition of a pressure gauge and calibration repair service, traceable to the National Bureau of Standards. . . . *Liberty Machine Co., Berlin, Conn., is offering a new service—round-the-clock atmosphere contamination monitoring for critical working areas. The service is available to firms located east of the Mississippi River. Liberty manufacturers white rooms and accessories.*

Missile/Space Facilities

Bourns, Inc., Riverside, Calif., producer of adjustment potentiometers, has announced plans to construct a manufacturing plant in Ames, Ia. The 67,000-sq.-ft. facility will be completed in mid-1965. . . . *Space & Tactical Systems Corp., Burlington, Mass., has expanded to a new plant at 45 Middlesex Turnpike. The building houses the Data Systems, Power Systems and Mechanical Systems Groups, as well as the firm's production facilities. SPACETAC manufactures miniature pulse-height analyzers, special power supplies and nuclear detection instruments for the missile/space industry.* . . . Electro Materials Corp., supplier of basic ceramic materials to manufacturers of ceramic capacitors, has moved into a 17,000-sq.-ft. building in San Diego, Calif. The firm will now enter full capacitor production. Joseph Crowther has been named manager and technical director of the new operation. . . . *Compar Los Angeles, affiliate of Compar Corp., has moved into a new office in Glendale, Calif. Compar is a nationwide organization of electronics manufacturers' representatives.* . . . Rohr Corp., Chula Vista, Calif., has installed a building-on-wheels for use in welding nozzle components being built for Thiokol Chemical Corp. Mobility was necessary so that components being built inside could be more easily removed. Rohr is a components manufacturer for the aerospace industry.

Company Representatives

IMC Magnetics Corp., Maywood, Calif., has appointed Engineering Components Co. as its engineering sales representative for upstate New York. ECC has offices in Syracuse and Binghamton, N.Y. . . . *Spectrol Electronics Corp., San Gabriel, Calif., has named Newark Electronics, Inc., Chicago, as distributor for its line of potentiometers, trimmers and dials.* . . . Edgerton, Germeshausen & Grier, Inc., Boston, has appointed Harry Levinson Co. as product sales representative in Oregon, Washington, Montana and parts of Idaho. Levinson is located in Seattle. . . . *Electro Materials Corp., San Diego, Calif., has named Compar Los Angeles as Southern California representative for its new line of miniature ceramic capacitors.* . . . Amprobe Instrument Corp. has named Industrial Instruments, Inc., Cleveland, Ohio, as sales representative for northeastern Ohio and northwestern Pennsylvania.

AWARDS

AIR FORCE

$34,500,000—**General Telephone and Telegraph Corp., Sylvania Electric Products, Inc.,** Waltham, Mass., for continued production of ground electronic system equipment for the sixth *Minuteman* wing.

$7,135,000—**Systems Development Corp.,** Santa Monica, Calif., for portions of electronic satellite-control systems.

$4,900,000—**Burroughs Corp.,** Detroit, for provision of 151 B263 electronic data processing systems for use at U.S. and overseas bases.

$1,130,000—**General Electric Corp.,** New York City, for research and development work.

$1,033,000—**Lockheed Aircraft Corp.,** Redlands, Calif., for a feasibility demonstration of a thrust vector control for Air Force propulsion systems.

$219,624—**Raytheon Co., Space & Information Systems Div.,** Bedford, Mass., for experimental satellite investigation of the ionosphere.

$204,400—**SFD Laboratories, Inc.,** Union, N.J., for development of manufacturing methods, processes and techniques for producing on a quantity-quality basis an X-band coaxial magnetron.

$151,540—**Thiokol Chemical Corp.,** Huntsville, Ala., for *Lance* rocket motors with igniters and shipping containers.

$150,000—**Rocket Power, Inc.,** Mesa, Ariz., for study of thermodynamic properties of rocket engine exhaust products.

ARMY

$2,557,872—**Firestone Tire & Rubber Co.,** New Bedford, Mass., for manufacture of high explosive anti-tank projectiles.

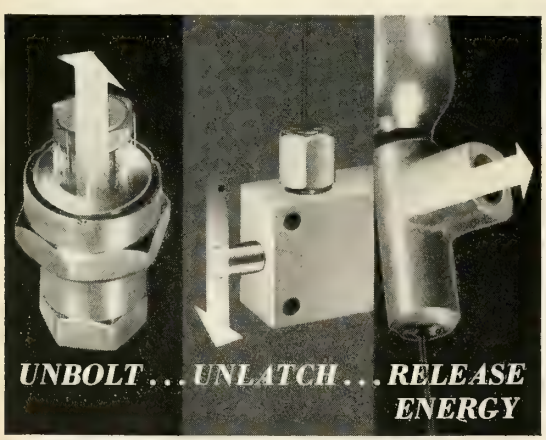
$1,615,111—**Western Devices, Inc.** Burbank, Calif., for 3,000 equipment consoles for the Moon launch complex on Merritt Island, Fla.

$1,360,000—**Hayes International Corp.,** Birmingham, Ala., for fabrication of *Sergeant* missile launchers.

$64,907—**Frank A. Kennedy, Inc.,** Cocoa Beach, Fla., for modifications to two launch complexes at Cape Kennedy.

$40,000—**Martin Co., Orlando Div.,** Orlando, Fla., for studies to refine its design for a new tactical communication system, Random Access Discrete Address (RADA).

$31,680—**Raytheon Co.,** Andover, Mass., for concurrent and replenishment repair parts for the *Hawk* missile system.



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Circle No. 25 on Subscriber Service Card

NAVY

$5,550,012—**Sperry Rand Corp.,** Great Neck, N.Y., for manufacture of navigation systems for three *Apollo* tracking ships.

$3,429,914—**Chroncraft Corp.,** St. Louis, Mo., for manufacture of rocket launchers for the Air Force.

$1,191,156—**Defense Electronics, Inc.,** Rockville, Md., for design, fabrication and assembly of two portable ship instrumentation packages for shipboard use in support of *Polaris* missile test operations.

$1,144,710—**Control Data Corp.,** St. Paul, Minn., for computer accessory equipment.

$788,289—**Hughes Aircraft Co.,** Culver City, Calif., for shipboard satellite communications sets for use with *Syncom II* and *Syncom III* space relay units.

$276,950—**Noser Construction Co.,** McAllen, Tex., for Rio Grande Space Surveillance Station.

$260,577—**Westinghouse Electric Corp.,** Washington, D.C., for molded foam wafers for the *Polaris* launcher.

$107,500—**General Electric Co.,** Washington, D.C., for provision of in-residence *Polaris* missile system field engineering services at the U.S. Naval Guided Missiles School, Dam Neck, Va.

$106,595—**Hughes Aircraft Co.,** Los Angeles, Calif., contract modification for engineering services for installation of MK 84 and A2 simulators.

$71,406—**Hughes Aircraft Co.,** El Segundo, Calif., for simulators for *Polaris A2* training program.

NASA

$496,000,000—**North American Aviation, Inc.,** Downey, Calif., for construction of spacecraft modules for the *Apollo* program.

$740,964—**United Aircraft Corp., Hamilton Standard Div.,** Windsor Locks, Conn., for *Apollo* pressure suit assemblies.

$360,000—**United Aircraft Corp., Research Laboratories,** East Hartford, Conn., for fundamental research associated with high-pressure rocket propellant pumps.

$353,000—**Avco Corp., Research & Advanced Development Div.,** Wilmington, Mass., for a micrometeoroid impact study.

$269,000—**General Motors Corp., Defense Research Laboratories,** Goleta, Calif., for experimental investigations of simulated meteoroid damage to various spacecraft structures.

$250,000—**North American Aviation, Inc., Space & Information Systems Div.,** Downey, Calif., for a study to determine system criteria for launch vehicle systems.

$121,280—**D. B. Milliken Co.,** Arcadia, Calif., for 16-mm motion-picture cameras to be used in the Project *Apollo* test program.

$107,000—**Vitro Corp., Vitro Laboratories Div.,** West Orange, N.J., for development of oxidation resistant coatings for use above 3,500°F.

$80,233—**Aerojet-General Corp.,** Sacramento, Calif., for boilerplate spacecraft spares and modifications.

$79,212—**Arthur D. Little, Inc.,** Cambridge, Mass., for study of the effect of the lunar environment on magma generation, migration and crystallization.

$77,460—**Atlantic Research Corp., Missile Systems Div.,** Alexandria, Va., for 60 sets of *Nike-Apache* fin assemblies and interstage adapters.

$65,111—**Aerojet-General Corp.,** Sacramento, Calif., for refurbishment of Algol rocket motor with cant nozzle.

$63,000—**Spacelabs, Inc.,** Van Nuys, Calif., for a propellant leakage detection system.

$49,957—**Hughes Aircraft Co., Hughes Research Laboratories Div.,** Malibu, Calif., for a R&D program for radiation measurements of radiological hazards of man in space.

$49,900—**Geophysics Corp. of America, Physics Research Div.,** Bedford, Mass., for study of lunar atmosphere detection and monitoring system.

$35,000—**Kaiser Engineers,** Oakland, Calif., for design criteria report for upgrading and space environment laboratory.

INDUSTRY

$4,500,000—**Giannini Controls Corp.,** Duarte, Calif., from **North American Aviation, Inc.,** Downey, Calif., for the design, development and production of a propellant quantity gaging system, capable of operation under zero gravity conditions, for the *Apollo* spacecraft.

$750,000—**Fairchild Camera & Instrument Corp., Precision Metal Products Div.,** El Cajon, Calif., from **North American Aviation, Inc., Space & Information Systems Div.,** Downey, Calif., for design, test and manufacture of LOX and liquid hydrogen flexible ducting for the S-II stage of the *Saturn V/Apollo* Moon-landing rocket.

$640,000—**Rantec Corp.,** Calabasas, Calif., from **Collins Radio Co.,** Dallas, for production of *Apollo* S-band tracking antenna feed systems.

$500,000—**Leach Corp.,** San Marino, Calif., from **North American Aviation, Inc., Space & Information Systems Div.,** Downey, Calif., for instrumentation data acquisition and storage units.

$430,000—**Microdot, Inc.,** South Pasadena, Calif., from **North American Aviation, Inc., Space & Information Systems Div.,** Downey, Calif., for stress measurement systems to be used in the operational *Apollo* spacecraft.

$320,000—**Microwave Electronics Corp.,** Palo Alto, Calif., from **Beech Aircraft Corp.,** Wichita, Kan., for supply of augmentor-type traveling wave tubes for expendable target drones.

$150,000—**Philco Corp., Western Development Laboratories Div.,** Palo Alto, Calif., from **California Institute of Technology, Jet Propulsion Laboratory,** Pasadena, Calif., for provision of engineering assistance in a program to advance the reliability of electronic components used in space exploration missions.

Textron Electronics, Inc., Heliotek Div., Sylmar, Calif., from **Hughes Aircraft Co.,** Culver City, Calif., for solar cell modules for *Early Bird* communications satellite (amount undisclosed).

REQUESTS FOR BIDS

GENERAL PROCUREMENTS

Directorate of R&D Procurement
Systems Eng. Group RTD
Wright Patterson AFB, Ohio

Fluid Dynamics Research involving operation of five supersonic wind tunnels, high pressure cabin/stand for component research and related systems at 3,000 psi. Major portion of work to be conducted at Aerospace Research Labs. RFP No. 516056-MA.

National Aeronautics and Space Administration
Manned Spacecraft Center
Houston, Texas 77058

NASA Manned Spacecraft Center is conducting negotiations with Litton Systems Inc., for a preliminary design of a constant volume hard suit assembly. This synopsis is for subcontracting purposes.

Purchasing Office
George C. Marshall Space Flight Center
National Aeronautics and Space Administration
Huntsville, Ala. 35812

Contractor must design, develop and pre-flight certification test pressure switches for Saturn V instrument unit. NASA proposes to issue RFQ 1-5-52-01051-01 on or about Sept. 10, with a period of 20 days to be allowed for submission of proposals. Proposals will be due Sept. 30.

Purchasing Office
George C. Marshall Space Flight Center
National Aeronautics and Space Administration
Huntsville, Ala. 35812.

Research and development engineering operation and fabrication services in support of the astrionics laboratory at Marshall Space Flight Center. RFP 1-5-40-50068 pre-proposal conference Sept. 11; RFP due date Oct. 16, 1964.

Directorate Procurement and Production
Middletown Air Materiel Area
Olmsted AFB, Penna.

Negotiations will be conducted with North American Aviation Inc., Autonetics Div., for contrchnical services for astro compass system. For information only; RFP not available.

Contracting Officer
National Aeronautics and Space Administration
Langley Station
Hampton, Virginia

Langley Research Center is negotiating a contract with William R. Bean for development of alloys for 1,200°F strain gages as a result of receiving an unsolicited proposal. For information only; RFP not available.

Bureau of Naval Weapons
Washington, D.C. 20360

R&D program directed toward design changes for Terrier weapons direction and ancillary equipment. BuWeps intends to solicit a proposal from Western Electric Co. For information only; RFP not available.

Directorate of Procurement FTMKR-6
Hqs Air Force Flight Test Center
Edwards AFB, Calif.
Attn: William J. Lyons

Negotiations are being conducted with Hercules Powder Co., Aerojet-General Corp., and Martin Marietta Corp. for the procurement of non-personal technical services or orientation and indoctrination in rocket production and production processes being performed by these contractors on Polaris, Titan and Gemini. Other proposals cannot be considered for this procurement.

National Aeronautics and Space Administration
Ames Research Center
Moffett Field, Calif. 94035

Negotiations will be conducted with the University of Pennsylvania for studies on plant morphogenisis under weightlessness. For information only; RFP not available.

Lewis Research Center
21000 Brookpark Rd.
Cleveland, Ohio 44135

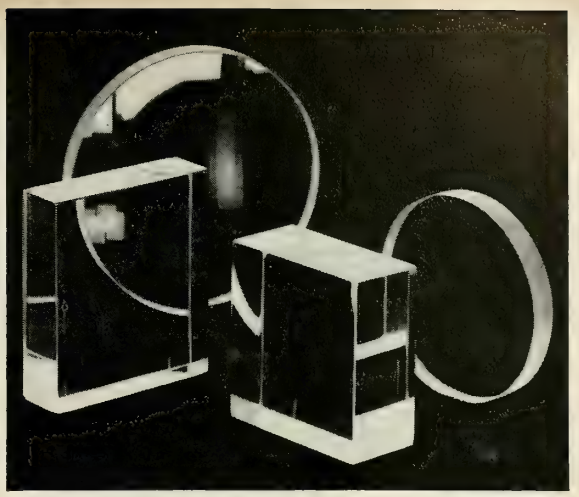
Negotiations will be conducted with Varian Associates, Vacuum Products Div. for the procurement of additional components to be incorporated into the vacuum system procured under Contr. NAS3-5753. For information only; RFP not available.

SBAMA (SBPAA) Aerospace Procurement Div.
Directorate of Procurement and Production
Norton AFB, Calif. 92409

Services to repair 2 LGM-25C missiles. Request for proposal has been issued to Martin Marietta Corp.

Purchasing and Contracting Officer
U.S. Army Missile Support Command
U.S. Army Missile Command
Bldg. 3152
Redstone Arsenal, Ala. 35809

Perform surface tolerance measurements on tracking antenna using the techniques of multistation analytical photogrammetric steriotriangulation method. For information only; RFP not available.



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General Electric's Type 151 fused silica is a high-purity optical material with exceptional homogeneity. It is ideally suited for laser, spectrometer and window applications requiring high transmission and minimum distortion. Its outstanding properties include:

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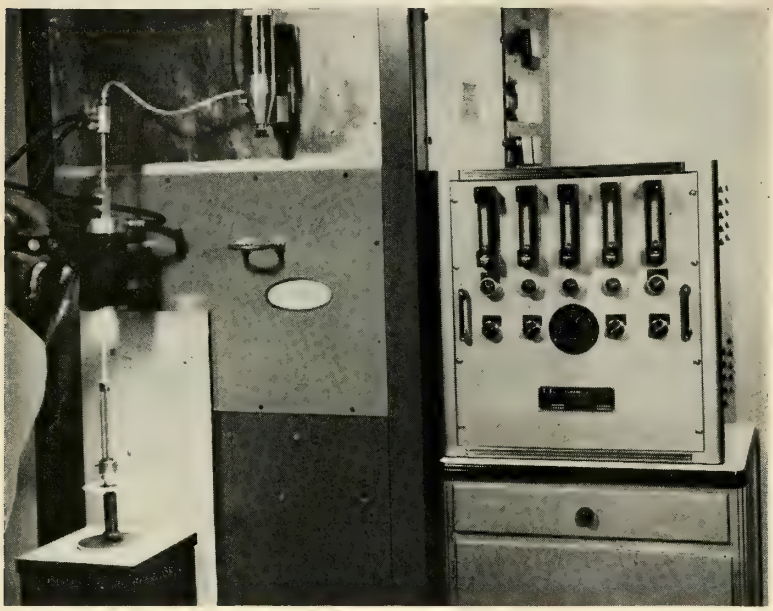
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Circle No. 26 on Subscriber Service Card



New Product of the Week: Single Crystal Grower

A precision Verneuil single crystal growing system has been developed by Humphreys Corp. for production and experimental growth of high-temperature single crystals using an induction plasma flame.

The system consists of a powder feeder designed to feed all types of free-flowing and caking powders onto the crystal as it is growing; a water-cooled induction plasma torch capable of operating on pure oxygen, air and nitrogen, as well as argon and helium; a seed crystal movement with mechanisms for crystal rotation, manual and electric up-down movement and two-way radial micrometer adjustment of the crystal. A high-temperature refractory muffle has been developed to minimize radiation from the crystal during growth and to allow slow annealing and cooling to prevent stress caking.

Circle No. 151 on Subscriber Service Card

Timing Receivers

A line of VHF/UHF fixed-frequency timing receivers has been developed by Simmonds Precision Products, Inc.

The Series 20000 receivers are crystal controlled and can be pre-tuned to a specified frequency anywhere within the 100 to 500 megacycle range. Noise figure is better than 5 db. The unit weighs 8 lbs. and measures 3.5 x 19 x 8.5 in.

Circle No. 152 on Subscriber Service Card

Aluminum Capacitors

Mallory Capacitor Co., a division of P. R. Mallory & Co., Inc., announced a new plastic molded tubular aluminum electrolytic capacitor line. Samples available immediately are ⅜″ x 1⅛″ axial lead sizes. Two additional case sizes—5/16″ x ⅞″ and ½″ x 1½″ are being tooled at present and will be available shortly.

Designated MTA units, the operating temperature range is −20°C to +65°C. The working voltage range is 3 WVDC-50WVDC. The capacity range in the ⅜″ x 1⅛″ size is 175 mfd. at 3 v to 20 mfd. at 50 WVDC, with a standard capacity tolerance of −10% to +100%. The d-c leakage is less than 0.03 microamperes per mfd. volt. Nonpolar units have a capacity range from 100 mfd. at 3 WVDC to 10 mfd. at 50 WVDC in the ⅜″ x 1⅛″ case size.

Circle No. 153 on Subscriber Service Card

Editing Device

Production of the first low-cost, automatic editing device has been announced by Infor/onics, Inc. EDITOR I permits rapid preparation and correction of data on perforated tape, in all areas where perforated tape is used.

It is a small, fast perforated tape processor that executes natural editorial instructions, as directed by push button from an "editor's console". A first-draft tape is read on the EDITOR's high-speed reader; this data is selectively copied, deleted, or re-formatted; new data is typed in as required; and a clean tape is produced by the EDITOR's high-speed punch.

The machine is compatible with any input-output keyboard or tape typewriter. It will accept and produce 5, 6, 7, or 8-channel tape up to one inch wide in any tape code.

Circle No. 154 on Subscriber Service Card

VHF Receiver

Kahn Research Laboratories, Inc., is marketing an advanced VHR receiver in two models, the 63-1A and 63-1B. Both are fluxed-tuned receivers featuring a signal-to-noise squelch operation called Auto-Select.

The 63-1A has a sensitivity of 1μv, yet radar pulse noise of up to 1v does not falsely operate the squelch, the firm says. The system is also insensitive to white noise. Crystal filter selectivity provides proper selectivity for 50-kc channel separation. Remote control features are included.

Circle No. 155 on Subscriber Service Card

Bandpass Filter

A fixed-tuned low frequency piezoelectric ceramic bandpass filter, approximately 0.1 the size of conventional quartz devices, has been announced by Piezoelectric Div. of the Clevite Corp.

The plug-in units provide bandwidths in the order of 1% at 6 db over a range of frequencies from 5 to 50 kc, the firm says. The filters can be utilized individually as four-terminal resonators or can be cascaded in pairs for more exacting signal selection and stop band rejection. Operating temperature range is −40° to 85°C.

Circle No. 156 on Subscriber Service Card

Semiconductor Laser

A CW semiconductor laser weighing 45 lbs. and featuring its own closed cycle cooling system has been introduced by Raytheon Co.'s Laser Advanced Development Center.

The gallium arsenide RSL4 delivers an output of up to 0.5 watt of continuous power at a wavelength of 8,400 Å in the infrared region. Electrical efficiency is 30%. Operating temperature of 30°K is achieved with a closed-cycle Norelco cooler driven by a 0.5-hp electric motor. Ordinary tap water is employed in the heat exchanger for the cooler.

Circle No. 157 on Subscriber Service Card

"Who is to bell the cat? It is easy to propose impossible remedies."
Aesop

To live safely with a tiger, you must know when he comes your way. It is MITRE's job to bell the cat.

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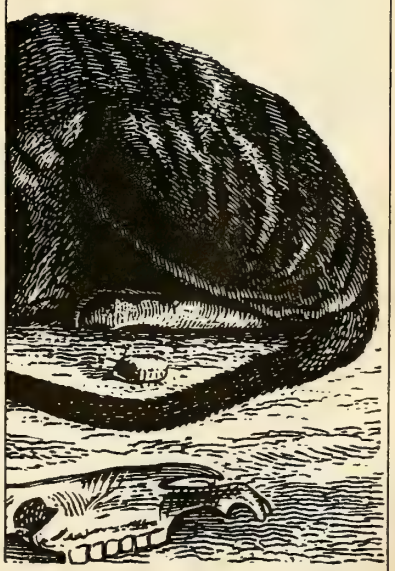
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Circle No. 27 on Subscriber Service Card

Infrared Detector

Fast scan rates and high resolution over a wavelength band of 2-15 microns are possible with a new infrared detector introduced by Raytheon Co. The QKN1266, which employs mercury-activated germanium, has both a time constant of approximately one microsecond and a high responsivity. It can be used in airborne and laboratory installations.

The detector has a transparent barium-fluoride window, an aperture area of 2.5 x 10^{-3} sq. cm., and a 45° acceptance angle. Average detectivity D*(500,900,1) is 4 x 10^{9} cm cps^{½} per watt. Noise equivalent power NEP (500,900,1) is 1.3 x 10^{-11} watts/cps^{½} and responsivity R(500,900,1) is 10^{4} to 10^{6} volts/watt, depending upon aperture size.

Circle No. 158 on Subscriber Service Card

Current Meter Reader

Geodyne Corp.'s flying spot scanner is available for reading current meter digital records. The reader output presents analog strip chart and IBM format magnetic tape. The 120,000 instantaneous readings of compass and vane obtained per 100 ft. film can be computer processed to give vector averaged directions. Averaged vector lengths are presented to indicate degree of angle scatter. As each rotor pulse is recorded and averaged, instantaneous speeds may be determined. Numerical printout, speed and direction histograms, trajectory summations, power spectra, N and E components may be plotted. Films from wind, temperature, and pressure instruments can also be read.

Circle No. 159 on Subscriber Service Card

Cermet Current Limiters

A new solid-state cermet current limiter, offering positive and predictable protection for semiconductor devices, featuring clearing time of less than 0.001 sec. at 316% of rated value, has been introduced by Electra Manufacturing Co.

Extreme speeds are accelerated by high operating temperatures due to a temperature coefficient of +2,500 PRM/°C. Cold resistance is 0.022 ohms to 13.5 ohms. It is 10,000 megohms (nominal) after firing. The device, called P-400, measures 0.250″ x 0.250″ x 0.125″ and is rated at 1/16 amp to 5 amps.

Circle No. 160 on Subscriber Service Card

Nixie Set/Reset Indicator

The G-104/N-1A is expressly designed by Coltronix, Inc., for those applications involving the parallel transfer of information in the 1-2-4-8 code into a digital display. Operating rates up to 110 kc are possible. In operation, a reset pulse is applied for one microsecond and an enable pulse for 30 mircroseconds. At the termination of the enable pulse, the information is registered and displayed. The reset and set enable pulses may be ac-coupled to provide the required pulse width discrimination. Both the reset and enable input functions and the 10 nixie output functions are isolated by buffer circuits for maximum flexibility and minimum circuit loading.

Circle No. 161 on Subscriber Service Card

Yoke Drive Amplifier

A yoke drive amplifier delivering 1.3 amps to a 1-millihenry, 1-ohm coil is available from Melcor Electronics Corp.

The transistorized Model 1309 was designed to sum up to 35 inputs and



to drive the deflection yoke of a CRT display. Features include a rise time of 90 microseconds and inputs of ±7.5v dc maximum from a 50 k ohm source.

Circle No. 162 on Subscriber Service Card

Double Pulse Flashtube

Edgerton, Germeshausen & Grier, Inc., has developed a flashtube double pulsing technique to assist laser users in obtaining more peak light output in the laser spectral region.

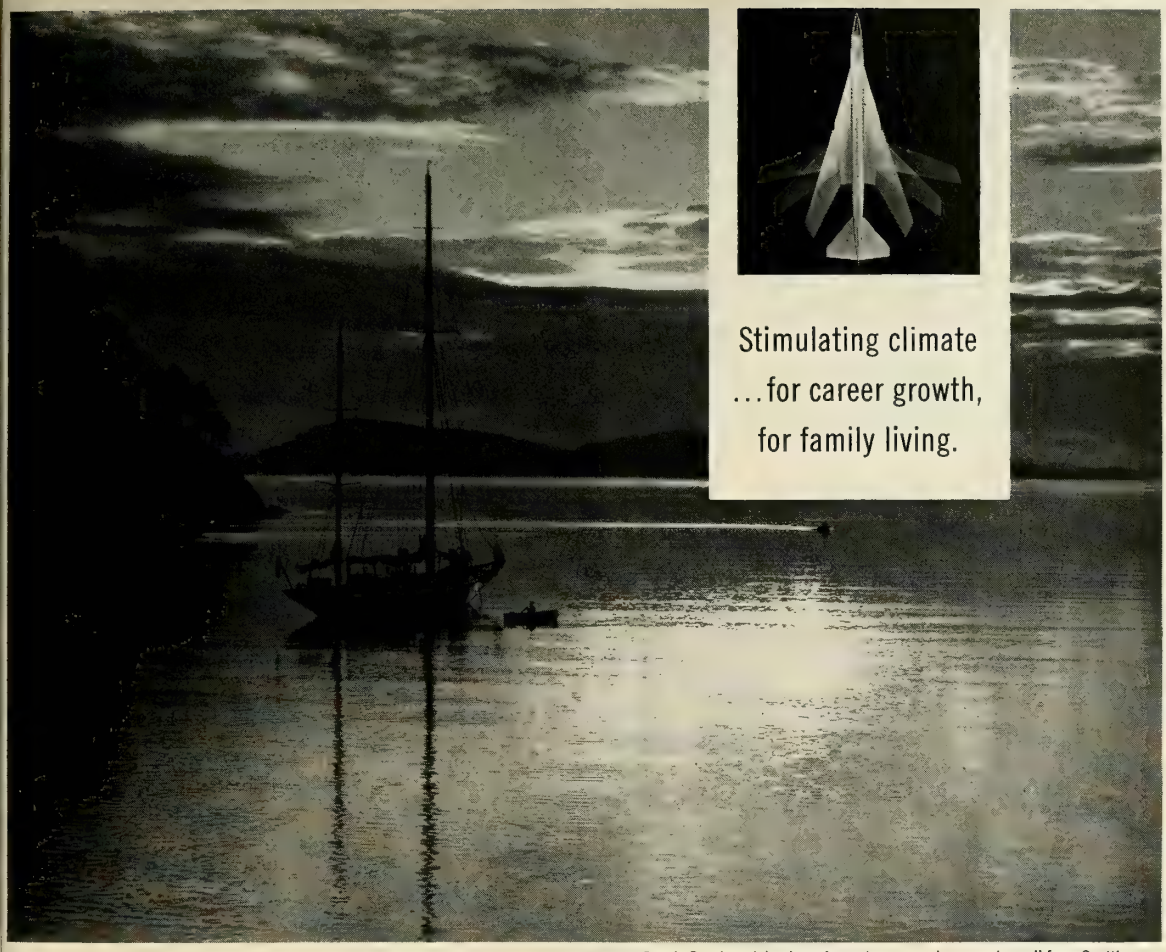
The flashtube switching circuit produces a double pulse 2.4 times the peak radiant energy obtained from previous pulse techniques, the company says. This is accomplished by driving a xenon flashtube with a low-voltage pre-ionizing, long pulse and then super-imposing a short, high-voltage pulse triggered 40 μsecs later. The pre-ionizing long pulse consists of 64 joules and is 1.5 μsec wide.

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Stability and Control Requires strong background in airplane flight control system design and analysis, and stability and control characteristics, plus knowledge of computers, servomechanism design and development and testing of airplane configurations. Master's degree or equivalent, plus 5 to 10 years of experience.

Flight Control Systems Assignments involve establishing dynamic design criteria and specifications for flight control systems, sub-systems and components; selection of most suitable control system components, and guidance of control system procurement and flight test. Requires B.S., M.A. or M.S. in engineering, mathematics or physics with 5 to 10 years' applicable experience.

Metallurgy Assignments entail alloy selection and application; development and improvement of processes; preparation of specifications; laboratory experiments; technical consultation, and service failure analysis. Requirements, in addition to 3 to 10 years' experience in aircraft technology or a related field, include familiarity with the electron microprobe and microscope and standard metallurgical equipment.

Mechanical Engineering Responsibilities involve development and improvement of processes through laboratory experiments; preparation of specifications; technical consultation with aircraft designers, vendors and subcontractors, and service failure analysis. Requirement: 3 to 10 years' experience.

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A miniature broadband transformer, 0.13 cu. in. in volume, has been developed by the Electronics Div. of Bulova Watch Co., Inc. for application as a balance mixer, balance modulator, ring modulator or for the output stages of linear exciters.

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C-Band Parametric Amplifier

A low-noise parametric amplifier designed especially for range instrumentation radars and telemetry applications has been announced by Microwave Physics Corp.

With the Model C-3, the bandwidth between the 1-db points is nominally 500 mc in the C-band region with the amplifier operating at 15-db gain. At 12 db, gain bandwidth is approximately 800 mc. The amplifier may be operating with as much as 20 db gain with some reduction in bandwidth. Ripple over the entire pass band does not exceed ±1 db.

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Compact Laser Diode

Maser Optics, Inc., has developed a laser device that is totally contained in a TO-18 transistor can. This new laser diode makes it possible for the first time for university and research laboratories to acquire precision equipment at reasonable costs for the study of the coherent radiation from the gallium arsenide laser diode.

The injection laser head can be operated at room temperature or at 77°K, through direct immersion in liquid nitrogen. Other major operational features include: low threshold current density and extremely high reliability under a broad range of operating conditions.

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THIS IS THE F111, the nation's new bi-service tactical fighter with a variable sweep wing and twin turbofan engines that contribute to multi-mission capabilities. General Dynamics/Fort Worth is the prime contractor on this and many other projects involving space vehicles and systems. Capable, qualified engineers and scientists are needed in our search for solutions to the problems encountered in our many and varied programs. We urge you to investigate the expanding opportunity to exercise your skills and knowledge in one of these projects by writing to Mr. J. B. Ellis, Industrial Relations Administrator-Engineering, General Dynamics/Fort Worth, P. O. Box 748-M Fort Worth, Texas. Your confidence is respected, of course. An equal opportunity employer.



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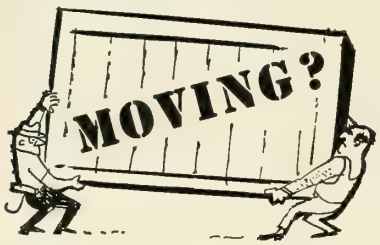
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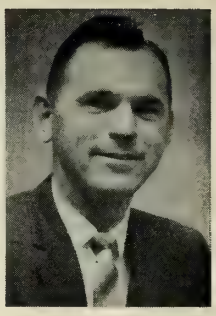
names in the news



GATES



MURPHY



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Cmdr. John O. Phillips: Appointed chief of the geodesy division of the Coast and Geodetic Survey. He will be in charge of all geodetic field survey parties, astronomic observatories and research on missiles and Earth satellites.

Duane T. Dahinden: Joined Electro-Optical Systems, Inc., Pasadena, Calif., as senior engineer. He will be responsible for prototype manufacturing and application engineering in the company's thermionics department, Energy Conversion Div.

Howard P. Gates, Jr.: Became special assistant for electronics and avionics for Willis Hawkins, Assistant Secretary of the Army for Research and Development. He was formerly vice president of Teledyne, Inc.

Howard Vollum: Awarded the Western Electronics Manufacturers Assn. Medal of Achievement for "notable achievements in electronics, and distinguished service to country and community." He is president of Tektronix, Inc., Beaverton, Ore.

C. Gordon Murphy: Appointed vice president of program management, Data Systems Div. of Litton Industries, Beverly Hills, Calif. He will be responsible for program planning and direction involving such projects as the marine tactical data system.

John H. Newitt: Appointed to the technical liaison staff of Manson Laboratories, Wilton, Conn. Manson is a division of Hallicrafters Co.

Kenneth R. Berg: Appointed manager of engineering at the Precision Metal Products Div. of Fairchild Camera and Instrument Corp., El Cajon, Calif. He was formerly with Northrop Corp.

Frank Gift: Promoted to chief engineer, International Rectifier Corp., El Segundo, Calif.

Francis S. Johnson: Appointed director of the Graduate Research Center of the Southwest's Earth and Planetary Sciences Lab. He was formerly with Lockheed Missiles & Space Co.

William A. Crawford: Elected president of the Instrument Society of America. He is principal instruments engineer with E. I. du Pont de Nemours & Co., Inc.

John C. Emala: Named to new post of field sales supervisor of Thiokol Chemical Corp.'s Chemical Operations, Trenton, N.J.

Richard Mascuch: Appointed president of Breeze-Illinois, Inc., of Wyoming, Ill., a div. of Breeze Corp., Inc., Union, N.J. He is also a director and vice president of the parent company.

Charles S. LaFollette: Elected assistant treasurer of Corning Glass Works, Corning, N.Y. Also elected was **James L. Flynn** to the position of assistant controller.

Edward A. Sommer: Appointed vice president of engineering in the Lindberg Steel Treating Co., Melrose Park, Ill. He will be responsible for production equipment design and development.

Donald R. Alt: Formed the Don Alt & Associates, public relations, in Huntington, Long Island, N.Y. His new organization will specialize in technical and financial public relations for companies in the Long Island area.

C. H. Sutcliffe: Joined the General Instrument Corporation, Semiconductor Products Group, New York City, as assistant group vice president for operations. He was formerly head of semiconductor operations for Philco Corp.

R. P. Gentry: Appointed assistant to the president of Sperry Gyroscope Co., Great Neck, N.Y. He was formerly Assistant Deputy Chief of Staff for Systems in the Air Force.

David Seltzer: Appointed executive vice president of Lundy Electronics & Systems, Inc., Glen Head, N.Y. He will be responsible for financial management for Lundy and its subsidiaries.

W. L. Emerson: Appointed general manager of applications engineering for Hexcel Products, Inc., Berkeley, Calif. He will supervise all regional applications engineers.

James E. Callahan: Joined Kollmorgen Corp., Northampton, Mass., following his retirement from the Navy. He will be chief project manager.

—when and where—

SEPTEMBER

Eighth International Convention on Military Electronics, sponsored by the IEEE, Shoreham Hotel, Washington, D.C., Sept. 14-16.

International Congress of Aviation & Space Medicine, Dublin, Ireland, Sept. 14-18.

German Rocket Society (Annual Meeting), Berlin, Sept. 14-18.

Symposium on Mass Spectrometry, sponsored by the Group for the Advancement of Spectrographic Methods, Paris, Sept. 14-18.

World Conference on Radio Meteorology, sponsored by the American Meteorological Society, National Bureau of Standards, Boulder, Colo., Sept. 14-18.

Techniques of Value Engineering for Defense and Space Contractors, sponsored by the National Defense Education Institute, Washington, D.C., Sept. 14-18.

First International Cellular Plastics Conference, sponsored by the Cellular Plastics Div. of the Society of the Plastics Industry, Inc., Barbizon Plaza Hotel, New York City, Sept. 14-18.

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Farnborough Revisited

LONDON

BRITAIN'S WELL-KNOWN Farnborough Flying Display and Exhibition, sponsored by the Society of British Aerospace Contractors, is fondly regarded by the British themselves as the shop window for the British aerospace industry.

Last week's display was the 24th since 1932, when the first was held at Hendon with 34 aircraft on hand and products displayed on trestle tables in two tents. Ever since SBAC moved the exhibition to the Royal Aircraft Establishment at Farnborough in 1948, the display has been known throughout the world as the "Farnborough Show."

It is justly famous and remains one of the world's outstanding aeronautical and astronautical events. This year was no exception. A record number of overseas guests attended.

Partly responsible for increased turnout was the fact that for the first time since World War II, Farnborough was not on an annual basis. The last show was held two years ago.

For those interested in missile/space developments, it appears even this pace may be too rapid. Farnborough was almost entirely devoid of new missile/space hardware. Missiles on display were those seen at previous Farnborough exhibitions one and two years ago. The British created more excitement and had more to unveil at the Paris Air Show two years ago than at their own show this year.

This is not said in condescension but merely to emphasize what the British themselves only now are beginning to grasp: the pace of today's missile/space effort in the United States and the Soviet Union is far, far beyond the capabilities of the United Kingdom, France, Germany or indeed any consortium of these countries.

Such missiles as *Thunderbird, Vigilant, Firestreak, Red Top, Blue Steel, Blue Streak, Seaslug* and *Seadart* are old hat in this industry and have been for some time, even in their latest versions.

There were, in fact, only three new missile developments at the show and none of these in hardware form. *Swingfire*, described as a second-generation wire-guided antitank weapon under development for the British Army, is not new to readers of this magazine. It was present only in mockup form.

Two other missiles were revealed in the week before the show. Both are in the planning stage and far from fruition. One is a joint air-to-ground tactical weapon, similar to *Bullpup*, being developed in conjunction with the French. It is interesting to note that even British and French official spokesmen could not agree on the cost for this program. With the Labor Party already challenging the agreement, it must be said that its future is nebulous at best.

Of the other new development, little has been said. This is ET 316, a new low-level antiaircraft guided missile system, probably with infrared guidance. Size of the contract to the British Aircraft Corporation was not announced. Although there is hope of sales to France and other countries, it does not appear that this can be considered a major program.

Pickings on the space side were even leaner. There was the *Blue Streak* missile, touted as the first stage of the *ELDO* vehicle, and there was a half-scale model of the *UK3* satellite to be launched with United States assistance. That was about it. *Blue Streak* does little but remind one that even the extremely capable Rolls Royce organization was heavily dependent on North American Aviation in development of the RZ2 engines which power the Hawker Siddeley vehicle. These are based on Rocketdyne engines. *Blue Streak* is indicative of strength of the British space effort. Under development for years, it first was launched in June of this year. The vehicle in a generous comparison would be placed in the *Thor* class.

Perhaps even more indicative of the space pace in the UK is the *Black Knight* research vehicle. This first was fired at Woomera in September, 1958—six years ago. In those six years, there have been just 17 launches.

WHAT IT ADDS UP TO IS THIS: Farnborough, even after a two-year hiatus, has amply demonstrated that Britain simply cannot afford to maintain the pace in the missile/space field. Any realistic, knowledgeable member of British industry is quick to admit this. The situation is not limited to Britain. It is true of France, Germany, Italy and any nation of the world other than the United States and Russia.

This is a hard pill for Britain and the others to swallow. Space is a prestige item. It is extremely difficult to forego national pride and acknowledge that the desire for a substantial missile/space effort far outruns the capability and willingness—particularly the willingness—to put up the ante in cold, hard cash.

It is difficult for the United States not to gloat about this in the international markets. As Shelley Berman said about Monopoly, there is nothing to match the sheer pleasure of clobbering a friend.

But if the United States must be gracious, then Britain must be realistic. The stakes are too high. The sights must be lowered. The power and the glory have moved elsewhere and the score at Farnborough in the missile/space field is an unhappy zero. The shop window was empty.

William J. Coughlin



Berthoud's Chronometer (French—18th Century) Courtesy Mariners Museum, Newport News, Virginia.

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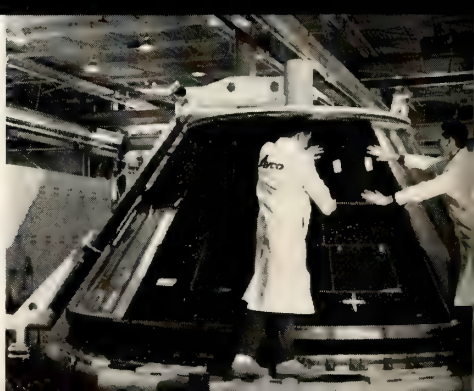
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SEPTEMBER 21, 1964

missiles and rockets

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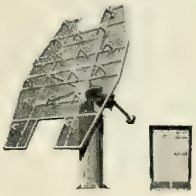
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FAN BEAM TRACKING SYSTEM

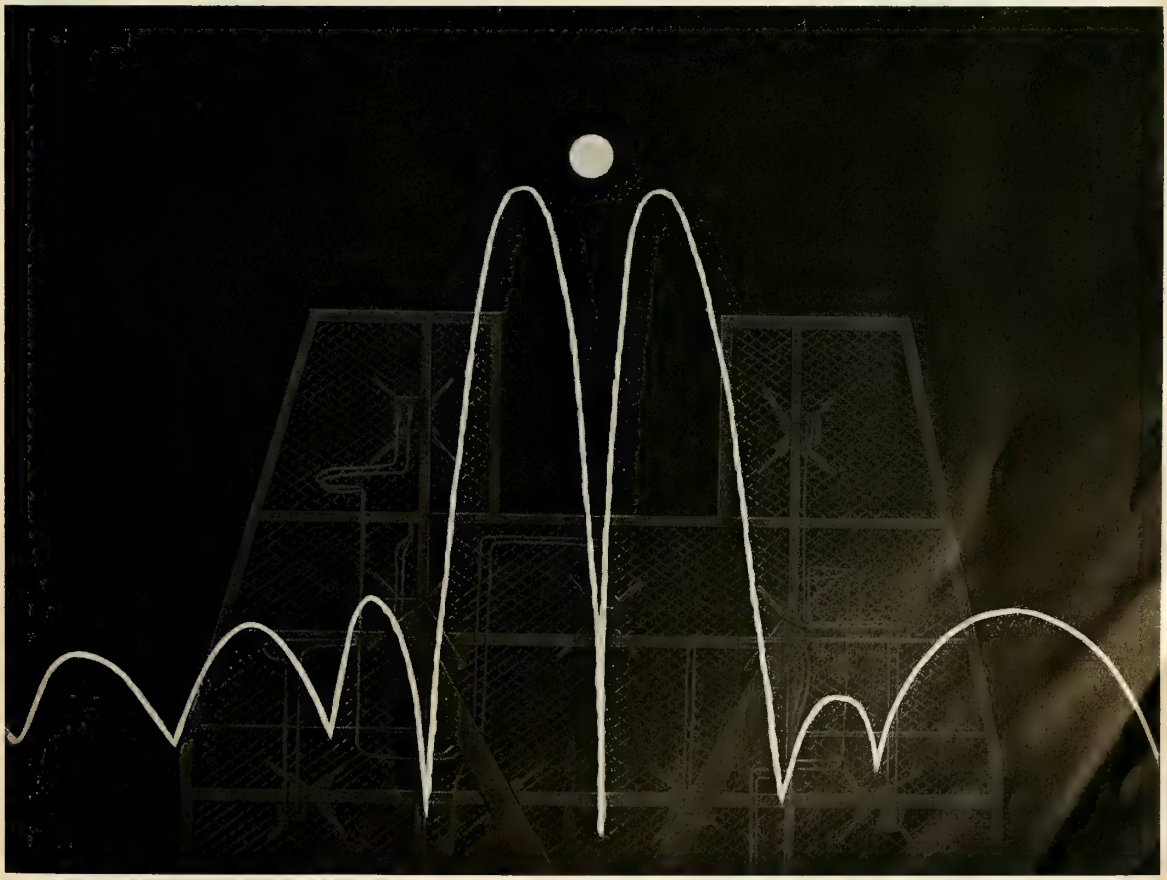
canoga

Constantly updating and improving its advanced tracking systems, Canoga has now created a new TELAR antenna array for the Canoga TELTRAC® telemetry tracking system. The result is TELTRAC II, a system which minimizes multipath at low elevation angles. The new fan beam array used in TELTRAC II has an elevation beam width of only 13 degrees at 260 mc. Lower frequencies have slightly wider beam widths. The difference pattern side lobes are below the peak of the sum channel pattern by 21 db. Overall tracking system performance is substantially improved. TELTRAC I with its octagonal crossed dipole array, and now TELTRAC II with the Fan Beam antenna shown here, are being produced in the 200 mc and 400 mc ranges and will be utilized for the follow-on MERCURY and GEMINI programs. These systems can be modified to meet other customer specified frequency ranges.

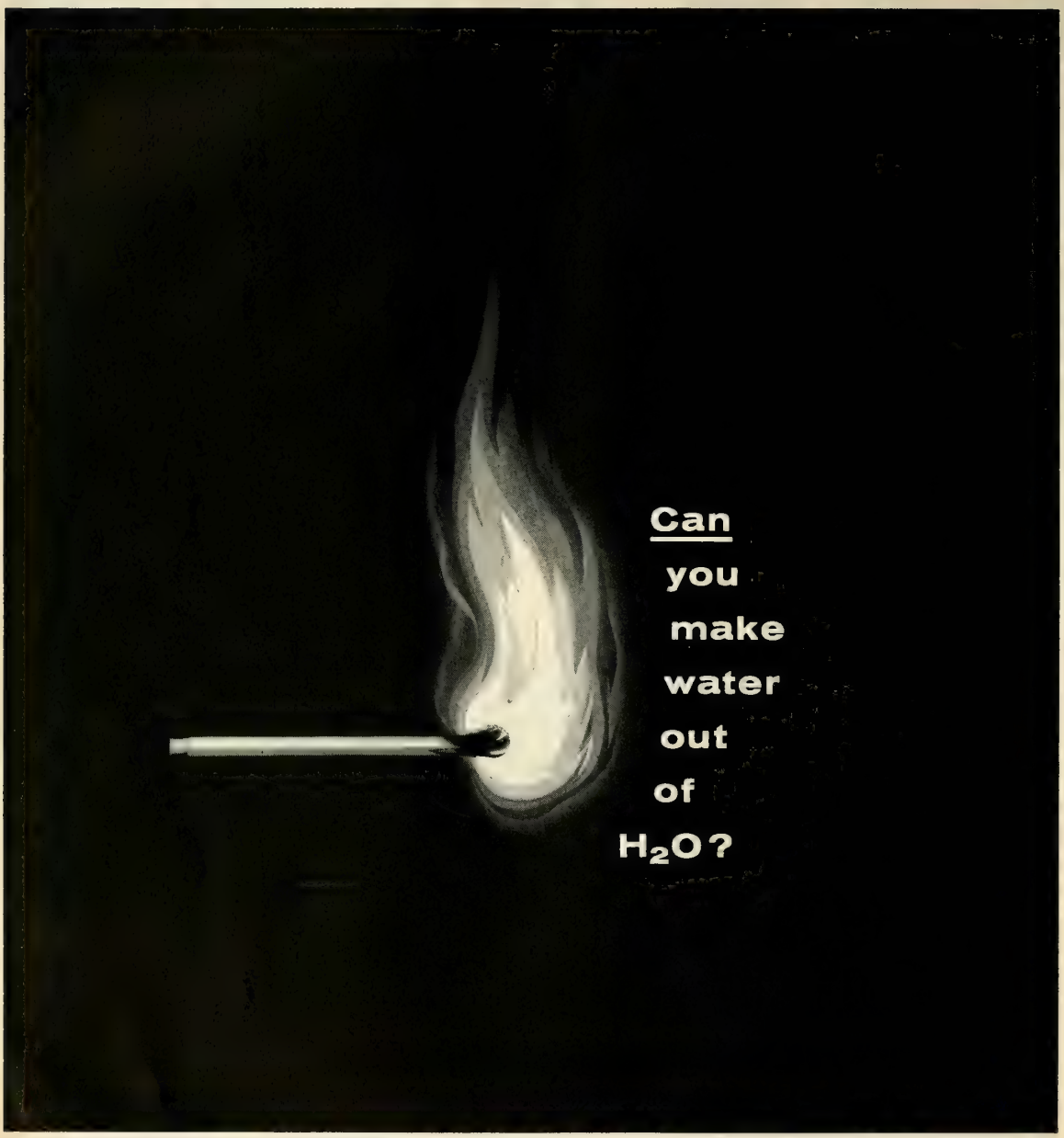


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Volume 15, Number 12 September 21, 1964

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Published each Monday with the exception of the last Monday in December by American Aviation Publications, Inc., 1001 Vermont Ave., N.W., Washington, D.C. 20005. Cable Address: AMERAV.

Printed at Judd & Detweiler, Inc., Washington, D.C. Second class postage paid at Washington, D.C.

Copyright 1964, American Aviation Publications, Inc.

Subscription rates: U.S. and Possessions, Canada, and Pan American Postal Union Nations: 1 year, $5.00, 2 years $8.00, 3 years $10.00. All other foreign: 1 year $15.00, 2 years $25.00, 3 years $35.00. Air freight to Europe: 1 year $20.00, 2 years $30.00, 3 years $40.00. Single copy prices: regular issues 50 cents each; special issues $1.00 each. Subscriptions are solicited only from persons with identifiable commercial or professional interests in the missile/space industry. Subscription orders and changes of address should be referred to Circulation Fulfillment Mgr., Missiles and Rockets, 1001 Vermont Ave., N.W., Washington, D.C. 20005. Allow 4 weeks for change to become effective and enclose recent address label if possible.

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THE COVER



The Lockheed P-3A Orion is a recent addition to U.S. ASW patrol forces. Capable of speeds up to 435 mph, the plane can "loiter" in an area at 170 mph. carrying 6,848 lbs. of ordnance and detection gear. M/R's special report on anti-submarine warfare begins on page 24.

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Compiled under the direction of Military Editor James Trainor

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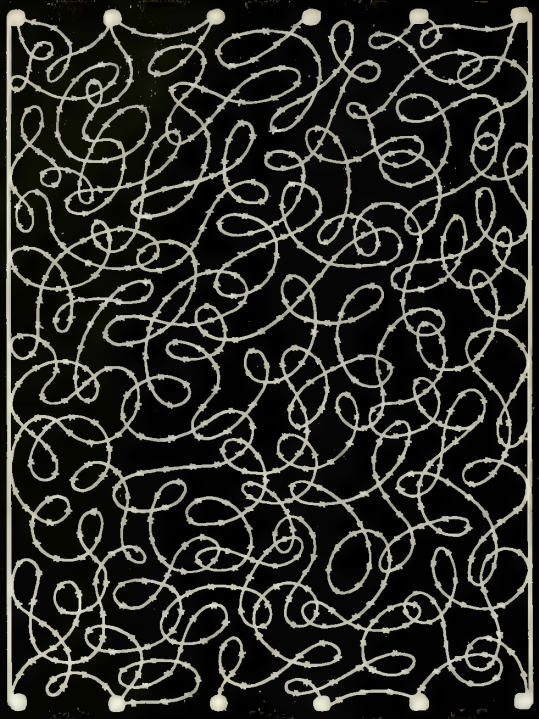
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Working with the Air Force to plan well ahead for the nation's needs in missile and re-entry systems is the vital national-defense mission of Aerospace Corporation. Specifically:

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You must get through this barbed-wire entanglement by making no more than six cuts in the wire. Plan ahead! (From *Mazes and Labyrinths, a Book of Puzzles*, by Walter Shepherd; Dover Publications, Inc., New York 14, N.Y.)

AEROSPACE CORPORATION

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letters

Back to the Drawing Board

To the Editor:

The following statement (slightly paraphrased for obvious reasons) appeared in a technical progress report on a research contract from one of our leading aerospace firms:

"We are now working on a third approach to the problem which will eliminate the poor assumptions of the first approach and the high cost of the second."

I was immediately struck with the general applicability of this candid statement to our approach to many of the space projects undertaken in this day and (space) age. It is offered simply as food for thought.

Clifford D. Coulbert
Tarzana, Calif.

Dubious Subscriber

To the Editor:

Please *do not* renew my subscription. Your vociferous bumbeling *(sic)* convinces me that you are uninformed. The only space program of which I am informed is *Ranger*. I can only assume that you carry your misrepresentation of facts to other program, thereby making your entire publication of dubious value.

Robert A. Schiffer
No. Hollywood, Calif.

Guiding Light

To the Editor:

You have been a guiding light—not necessarily popular with Bobby McNamara but your straightforward views are surely appreciated by Industry. NASA/AF/Army /Industry has to have a clearing house of information without the cloak-and-dagger type systems. Our potential enemies get most of the information they want from the technical, general periodicals which we so generously provide. I have been at meetings where you spoke—and boy, you are good. Cancellation of so many defense programs necessarily should make Government and Industry take stock of what is going on—after Elections, of course, or even before! It is time for McNamara to return to management of auto production.

I am a longtime subscriber to M/R and member of AIAA.

Robert Crowder
Washington, D. C.

Goldwater's 90%

To the Editor:

Your editorial "The Calculated Truth" (M/R, Aug. 17) was excellent.

True, present weapons were planned and funded by previous administrations. However, let's examine this statement: "Sen. Barry Goldwater's charge that U.S. deliverable nuclear capability may be cut by 90% under present Administration policies is totally unsupported."

On page 12 of the same issue Sen. Goldwater's actual statement on the 90% cut includes the words "in the next decade." If the manned bombers are phased out by 1974, with no *LASV* or comparable development (page 8 of the same M/R issue), the tonnage deliverable could very well be reduced. But careful reading of Goldwater's statements shows that he is not referring to a 90% cut from *present* levels but from levels that could and should be available by 1974. As such his 90% cut figure is entirely reasonable.

Failure to pursue the practical Project *Orion,* with its 1,000-ton payloads, could alone account for 90%. Project *Orion* was dropped by the Administration largely because its own nuclear test ban treaty (which Russia will ignore when to their advantage) prevents development. This, in spite of the fact that 10,000 Orion missiles, with their 1,000-ton payloads, could blast off from Earth using atomic propulsion without equaling the radioactive atmospheric poisoning added by Russia megaton bomb testing in a single recent year. The simple *Orion* missiles could have been in production by now, putting us on the Moon in force, as well as maintaining the peace.

We can think of several other projects that have been dropped.

When viewed in full perspective, Sen. Goldwater's contentions make sense, as they always do when he disagrees with the civilian, news-managing bosses of the Pentagon.

T. M. Morse
Santa Maria, Calif.

New Mexico Symposium

To the Editor:

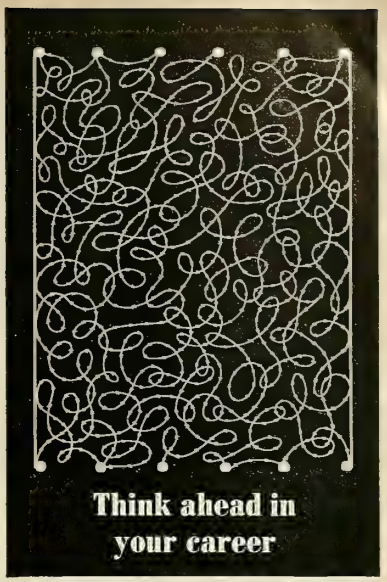
This letter's purpose is to provide additional information concerning the Symposium, "Aerospace Frontiers in New Mexico," to be held Oct. 15-17 at the University of New Mexico under the sponsorship of the University and the New Mexico section of ASME, in conjunction with the University's 75th birthday.

Some of the areas covered in the symposium will be research at New Mexico universities related to aerospace, Air Force programs at Kirtland AFB and Holloman AFB, Army rocket programs at White Sands Missile Range and programs related to aerospace at Sandia Corp., ACF Industries and Los Alamos Scientific Laboratories.

Some of the key speakers will be Dr. T. L. Popejoy, president of the University of New Mexico; Col. Sorte of the Air Force Weapons Laboratory at Kirtland; Dr. John Hornbeck, president of Bellcomm, Inc.; and Dr. William W. Carter, Chief Scientist, U. S. Army Missile Command, Redstone Arsenal.

The Symposium contact for registration and reservations is R. J. Hart, 2136 Martha NE, Albuquerque, N. M. Phone 299-0669, Area Code 505.

John D. Bert
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Despite complexity of the problems, real progress is being made in the study of this environment. For more information on Vitro capabilities in oceanography, contact Owen E. Cunningham, Vitro Laboratories, 14000 Georgia Avenue, Silver Spring, Maryland, (301) 942-7200.

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The Countdown

WASHINGTON

First DOD Comsat Due for Early '66 Launch

The first military communications satellite is expected to be launched into a near-synchronous orbit by a *Titan-III-C* early in calendar year 1966, according to present plans. Tom Rogers, assistant director for communications electronics in DDR&E, told the International Convention of Military Electronics (MIL-E-CON) in Washington last week that the Pentagon had concluded that a medium-altitude, random orbit system was best for its purposes. Three *Titan III-C's* are to be used, each putting six to eight satellites in near-equatorial 19,000-n. mi. orbits. If the *III-C* is not yet available, plans will be changed to allow a switch to an *Atlas-Agena* booster.

MILA Support Choice Still Weeks Away

It will be at least two more weeks before the Kennedy Space Center makes its selection of a firm to perform launch support services at NASA's Merritt Island Launch Area. Six firms—Aerojet-General, Westinghouse, Bendix, General Dynamics/Astronautics, American Machine & Foundry and Chrysler—are competing for the award.

Apollo Chute Trouble Lingers

NASA is still experiencing trouble with the parachute recovery system for *Apollo*. One proposed solution—placing a 10-ft. parachute inside the main 84-ft. chute in an effort to get greater distribution of the pull of impact—failed to prevent the breaking of the risers. A full-scale test has been put off indefinitely pending further study of the problem.

MSFC Lab Bids Sought Next Month

Marshall Space Flight Center has asked 116 firms to submit bids on an engineering and technical support contract for its Research Projects Laboratory. Bids are due Oct. 30. A pre-proposal conference is scheduled in Huntsville, Ala., on Sept. 22.

New Ground Speed Mark Set at Holloman

AF Missile Development Center reports that a seven-foot monorail sled reached 4,200 mph—fastest speed ever attained on the ground—during a captive test at Holloman AFB. Purpose of the run was to explore problem areas for future projects requiring hypersonic test sleds.

AEC Tightens Contract Appeal Handling

Atomic Energy Commission has established a Board of Contract Appeals, effective Oct. 10. Other rules changes include mandatory conferences with the Board by firms appealing contract decisions and elimination of any further appeals to the AEC.

JCS Conducting Communications Drill

High Heels III—a global communications exercise—is being carried out by the Joint Chiefs of Staff. Purpose is to ensure responsiveness of worldwide communications systems and reporting procedures under conditions of enemy attack. Essentially a command post exercise, High Heels III involves commands of all the armed forces and JCS. It will be concluded later this month.

U.S. Batting .850 in Orbits

In the past three years, the U.S. has been successful in 85% of its attempts to orbit payloads. Some 80% of the launches were made by the military and the rest by NASA. Another new statistic released by Dr. Edward C. Welsh, acting chairman of the National Aeronautics and Space Council, is that since January, 1963, the U.S. has placed more payloads in orbit than the Soviet Union has since *Sputnik I* in 1957.

INDUSTRY

Douglas Gets MORL Power Study

Douglas Aircraft Co. has been selected for an investigation and preliminary design of an integrated isotope power supply for a *Manned Orbiting Research Laboratory*. Contract was awarded by the Langley Research Center. NASA headquarters also is negotiating with Space-General Corp. for a study of unmanned applications for SNAP power units.

Edwards AFB Probing Air Augmentation

Air Force Flight Test Center at Edwards AFB is negotiating with the Denver Div. of Martin Co. for continuation of work on air augmentation systems. Contract calls for coordination and monitoring of programs looking into such augmentation of boosters—a system which could cut down the size of existing boosters substantially.

Army Awards Thiokol MAW Contract

Army Missile Command has awarded a contract to Thiokol Chemical Corp. for engineering services—drafting and engineering design of components—for a directionally controlled *Medium Antitank Weapon* exploratory development program. This is the AMC entry into the *MAW* competition. Thiokol was the supplier to Douglas of 40 motors for the Arbalest project—a high-energy, hypervelocity propellant test program. Award is further confirmation of M/R's report that this was the route chosen by AMC for the *MAW* requirement.

INTERNATIONAL

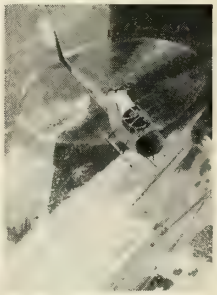
Dutch Are First Sea Dart Customers

Britain's *Sea Dart* ship-to-air missile is now being purchased by the Netherlands for installation aboard specially designed Dutch frigates. The Dutch thus become the first foreign customer for the Hawker Siddeley Dynamics CF. 299, a medium-range missile being developed to NATO specifications by the Royal Navy. Holland Signal Aparaat of Hengelo will join a number of British subcontractors in providing electronics equipment.

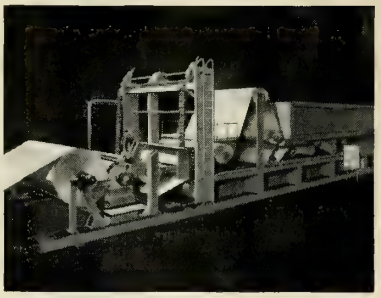
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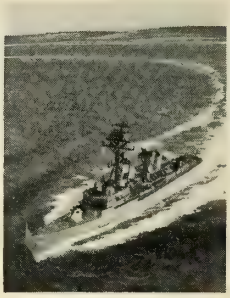
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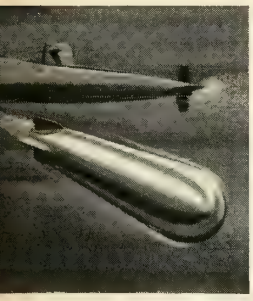
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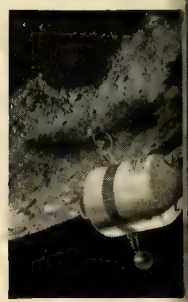
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Defense RDT&E Shows Drop

For the first time since the category was begun in 1956, Defense Dept. experimental, developmental, test and research work declined from $5.687 million in FY '63 to $5.145 million in FY '64. Most of this decline was accounted for by a drop-off in missile expenditures, DOD said in a report on Defense Procurement from Small and Other Business Firms.

Missiles also accounted for the major drop in procurement dollars in FY 1964. Net defense procurement declined $873 million in FY 1964, but missiles took a sharper drop of $1.11 billion and other military hard goods were off $267 million. A $507-million gain in services, soft goods and civil functions offset some of these losses.

Small business, the report said, obtained $4.842 million in prime contract awards during FY 1964 for military and civil functions combined.

Navy Solicits Condor Proposals

Proposals for the project definition phase of the *Condor* air-to-surface missile will be solicited from nine firms, the Bureau of Weapons announced. There was no indication how many contracts would be let on the much-delayed program.

Firms being solicited are: Martin-Orlando, Douglas Aircraft, McDonnell Aircraft, Hughes Aircraft, North American Aviation's Columbus Div., Northrop Corp., Raytheon Co., Grumman Aircraft Engineering Corp. and Bendix Corp.

Condor is reported to be a 40-mi.-range missile destined for use on the F-111 B and A-6A aircraft.

120-in. Solid Set for Firing

A 100-ton solid-grain motor, 120 in. in diameter and 30 ft. long, was scheduled for firing Sept. 21 at Aerojet-General Corp.'s Dade Div. south of Miami, Fla.

The motor is expected to produce 600,000 lbs. thrust in the special cast/cure and test pit. Data from the firing will be used in preparing the 260-in.-dia., 80-ft.-long, 3-million-lb. motor, test firing of which will climax the Air Force's Large Solid Rocket Demonstration program at Aerojet next spring.

A 12-man test team from the firm's Sacramento facility has been preparing the 120-in. test motor. This group will remain at Dade for two subsequent tests of the 260-in. ignition motor. The igniter motor for the larger booster generates 280,000 lbs. thrust while shooting flame a distance of 80 ft.

In the nose-down 260-in. static firing, the igniter motor will fly out of the larger unit's nozzle in a controlled arc with a final impact point in the Florida swamps. Huge cables will hold the igniter motor during its captive escape.

SECOR Amends U.S. Maps

First operational test results from the Army's *SECOR* international geodetic satellite surveying system show deviations from the generally accepted locations of various points in the United States.

Preliminary data from the system, developed by the Army and the Cubic Corp. of San Diego, Calif., were reported by Brig. Gen. Thomas J. Hayes at the Tenth Congress of the International Society of Photogrammetry in Lisbon, Portugal, recently.

SECOR uses a satellite some 600 mi. in space to plot locations with unprecedented accuracy.

Hayes said the U.S. testing phase has disclosed "interesting new information." For instance, he said, "we discovered that the accepted geodetic survey information for Ft. Carson, Colo., differed from our computations by 2 ft. 3 in. in latitude, 23 ft. 3 in. in longitude, and 18 ft. 3 in. in elevation."

Kiwi B4E Restarted

A major step in the development of nuclear rockets was taken on Sept. 10 when the Kiwi B4E reactor was restarted successfully.

The reactor was first operated successfully on Aug. 28 when it ran for eight minutes. During the restart operation, it ran at full power for more than two minutes.

OGO 'Two-Thirds' Successful

NASA's *Orbiting Geophysical Observatory (OGO-I)* has been declared two-thirds successful by space agency officials and is sending back 50 to 75% of the hoped-for data.

At a briefing last week in Washington, officials from Goddard Space Flight Center said that in terms of bits per second, the 1,073-lb. *OGO* is transmitting as much information as 10 to 20 *Interplanetary Monitoring Platform's*. All 20 experiments have been turned on, but four are not transmitting meaningful data.

OGO-C, the next satellite in the series, is scheduled to be launched into a polar orbit early next year.

K Claims Super Weapon

A "monstrous new terrible weapon," was discussed by Soviet Premier, Nikita S. Khrushchev, when he met last week with a delegation of Japanese legislators. The device "is a means of the destruction and extermination of humanity," the Soviet leader said.

Khrushchev appeared to be trying to scare the Communist Chinese, rather than the U.S., with the announcement. He coupled the statement on the weapon with a denunciation of red Chinese leaders and the assertion that "our boundaries are sacred and inviolable and any attempt to change them by force means war."

U.S. officials disclaimed any knowledge of a new Soviet weapons development and felt that it was more a propaganda device than a real "doomsday machine."

LBJ Visits Cape

President Lyndon B. Johnson paid a short visit to the Kennedy Space Center Sept. 15 during which he declared that the U.S. would never be second to any nation in space.

He arrived on Sept. 15 and spent about one hour and 50 minutes being briefed on the *Mariner*, *Gemini* and *Apollo* programs.

GT-3 Officially Slipped

Any possibility of a manned *Gemini* launch in 1964 has been eliminated by weather complications, NASA announced last week.

Lightning damage to the *Gemini-Titan* launch vehicle and safety precautions taken during Hurricanes Cleo and Dora pushed the unmanned *GT-2* flight from the third to the fourth quarter of this year. The manned *GT-3* shot has been scheduled for the first quarter of 1965.

Shots of the Week

The Air Force on Sept. 14 launched a secret satellite toward polar orbit aboard a *Thor-Agena* booster. The *Discoverer*-type shot was from Vandenberg AFB, Calif.



Another fuel cell application/success report from Allis-Chalmers:

World's first fuel-cell operated submarine!

July, 1964, Groton, Conn.: Star I — a one-man test and research submarine — was successfully operated both submerged and on the surface. An Allis-Chalmers 36-volt fuel cell produced 750 watts to power the vessel's electric drive motors, communications, navigation, life support and lighting equipment.

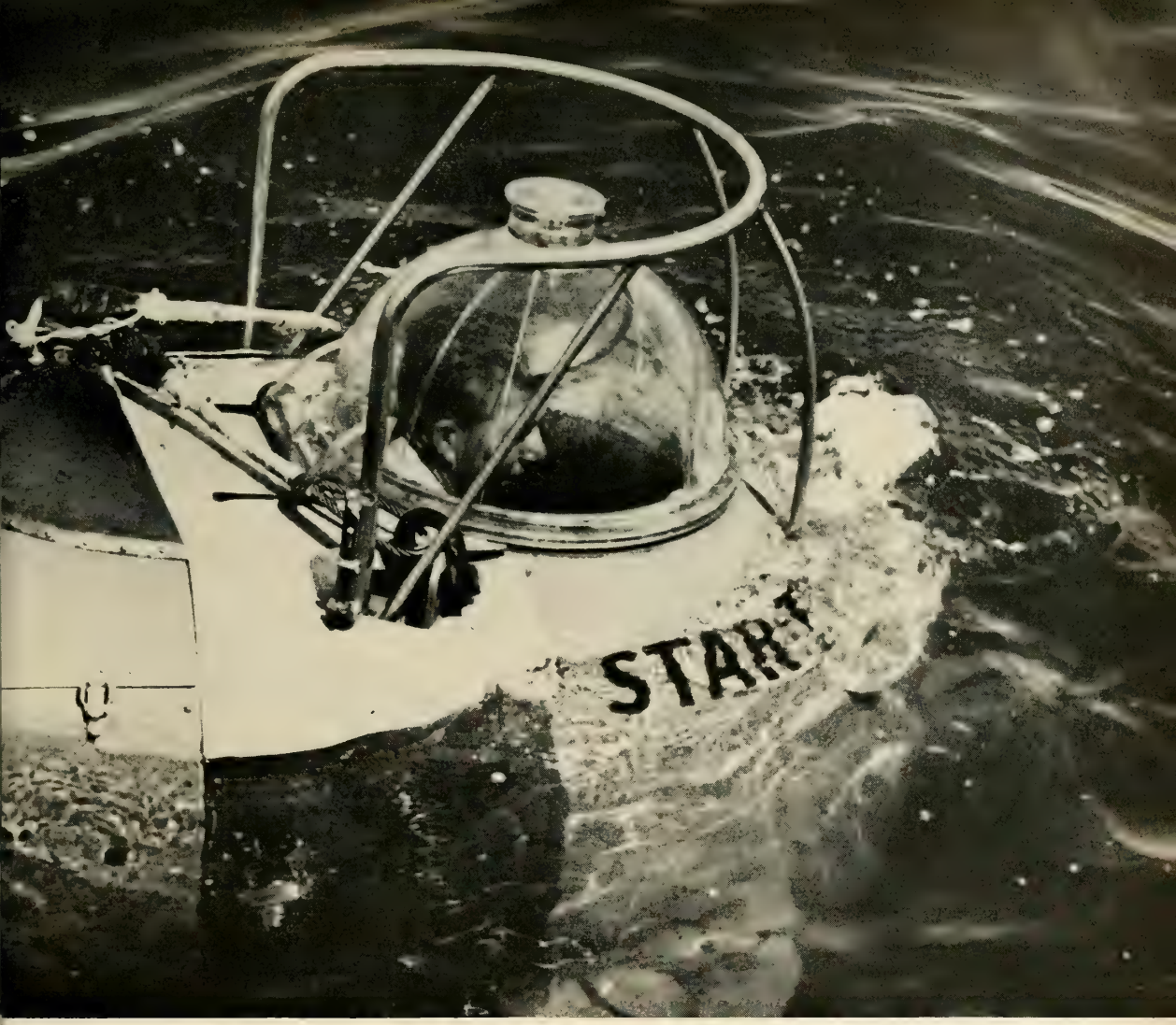
Star I — owned and operated by General Dynamics/Electric Boat Division — was powered by an Allis-Chalmers fuel cell system. It is a nine-foot-long, teardrop shaped 2,500 lb. submarine. A-C and Electric Boat Research engineers teamed up to successfully adapt fuel cell power to the submarine. Purpose: **to extend the vessel's capabilities beyond those of conventional storage battery power.**

In effect what the fuel cell has demonstrated was to double the Star I's endurance time. Previously batteries lasted up to 4 hours and required 8 hours to recharge. In the fuel cell, endurance is measured by the quantity of fuel and oxidant aboard and only five to ten minutes are sufficient to change to a fresh supply of hydrazine (the fuel) and oxygen (the oxidizer).

And this new Allis-Chalmers fuel cell application follows on the heels of A-C's 14 lb. hydrogen-oxygen fuel cell developed for the Air Force. This cell qualified for orbiting. It's scheduled to produce electrical power for systems aboard aerospace vehicles.

May we discuss your aerospace or defense fuel cell application? TELEPHONE AREA CODE 414-774-3600, EXT. 491, ALLIS-CHALMERS, Box 512, Milwaukee, Wis. 53201. A-1939

ALLIS-CHALMERS





The compact Allis-Chalmers fuel cell is ready for lowering into the non-pressurized glass fiber fairing behind the STAR I's four-foot spherical pressure hull.



In July, 1964, the 9-foot long STAR I, powered by A-C fuel cells, operated successfully both submerged and on the surface.

Quick summary:
ALLIS-CHALMERS FUEL CELL FIRSTS

FIRST

. . . in a land vehicle, a 15-kw tractor 1959

FIRST

. . . to successfully pass zero gravity tests, Wright Patterson AFB 1961

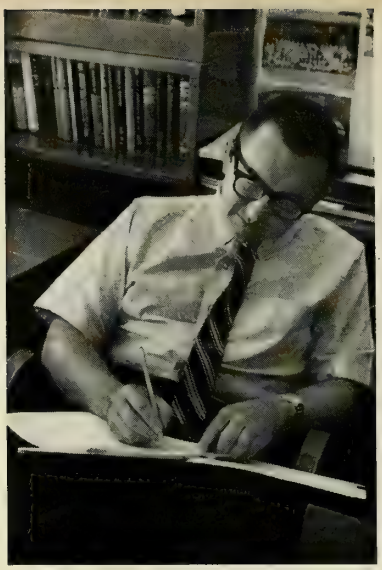
FIRST

. . . "qualified for space" fuel cells for the Air Force. . . . March, 1964

FIRST

. . . to power an underwater vehicle . . . . . July, 1964

FUEL-CELL design for Aerospace and Hydrospace applications is but one of the opportunities open today for qualified scientists and engineers at Allis-Chalmers. For information concerning employment write to: Manager of Professional Placement, Allis-Chalmers, Milwaukee, Wisconsin 53201.



What will John Burr do today?

1. **Save his firm a million dollars?**
2. **Work on a book about tracer applications in organic chemistry?**
3. **Grab a jet and address a conference in Kyoto?**
4. **Consult with engineers on radiolysis of cyclohexane in the presence of benzene?**
5. **Advise the firm's Geneva representative by phone?**
6. **Study a paper on ultrasonic attenuation by chemical reaction?**
7. **Discuss an esoteric molecular structure?**
8. **Lecture on structural chemistry in a university classroom?**
9. **Explore the interaction of ionizing radiation with organic materials?**
10. **Or just gaze out the window and think?**

It's difficult to say what John will do today. His career permits exceptional latitude.

John G. Burr—BS, MS, Ph.D—is typical of more than half-a-hundred scientists actively engaged in fundamental research at the North American Aviation Science Center. Here, inquisitive men like John conduct theoretical and experimental work at the forefront of their chosen scientific disciplines. North American provides them with an environment designed to stimulate their natural scientific creativity.

With this freedom these men explore the scientific nuances which may ultimately benefit all of mankind. Some study the structure of blood, using exotic new tools of physics such as the Mössbauer Effect; others map the symmetrical contours of Fermi surfaces of metals to study their physical properties. Some ponder the extraction of economical electrical energy from the inferno of the atomic reactor; others assist in the science underlying microminiaturization in solid state electronic systems.

And while fundamental research expands scientific horizons, it accelerates America's economic growth through new jobs, new products, new industries. Creating the groundwork for progress like this demands unusual corporate foresight.

North American Aviation

At work in the fields of the future through these divisions: Atomics International, Autonetics, Columbus, Los Angeles, Rocketdyne, Science Center, Space & Information Systems

Ruina Taking Top Post at IDA

by James Trainor

ANOTHER ATTEMPT is to be made to smooth the working relationships between the Dept. of Defense and its high-powered, non-profit study group, the Institute for Defense Analyses (IDA).

Dr. J. P. Ruina—former head of the Advanced Research Projects Agency—will replace Richard M. Bissell as President of IDA early in October, MISSILES AND ROCKETS has learned. Ruina's selection as president of the institute will be verified at a meeting of the Board of Directors Oct. 22.

Ruina has already relinquished his post in the physics department at the Massachusetts Institute of Technology and is in Washington preparing to assume the $45,000-a-year job as IDA president. Bissell was out of town last week and could not be reached for comment.

The move is seen as an effort to bring into closer harmony the Weapons System Evaluation Division of IDA and the Weapons Systems Evaluation Group of DOD. In the past, there has been considerable friction over the delineation of responsibility for WSEG reports.

The two groups, conducting operations research studies and system analyses for both the Joint Chiefs of Staff and the Director of Defense Research and engineering, are so closely meshed in their day-to-day operations that it often is impossible to distinguish military inputs from civilian. Yet IDA must produce a product to justify its existence to Congress—and the military feel that they, too, must be responsible for, and given credit for their inputs.



Dr. J. P. Ruina

Ruina's appointment is expected to alleviate some of the friction between the two groups. As director of ARPA from January, 1961, to August 31, 1963, Ruina became a close friend and advisor to Dr. Harold Brown, who, as head of DDR&E, administers the IDA contract. Brown, in fact, consulted Dr. Ruina even after the latter had left the Department, according to Defense officials.

An electrical engineer, Ruina served as Deputy for Research to the Assistant Secretary of the Air Force (Research and Development) from February, 1959, to May, 1960, and subsequently as Assistant Director of Defense Research and Engineering (Air Defense) until his appointment as head of ARPA in 1961.

Born in Poland in 1923, Ruina came to the U.S. in 1927. He received a B.S. degree from College of the City of New York in 1944, a master's degree and doctorate from the Polytechnic Institute of Brooklyn. His technical specialties have included work in the fields of noise and communications theory, radar systems design, backscatter and antennas and propagation.

Richard Bissell—trained as an economist at Yale—became president of IDA on July 10, 1962. Prior to that he had been a deputy director of the Central Intelligence Agency. His involvement in the abortive Bay of Pigs invasion of Cuba in 1962 led to his leaving the CIA.

● **IDA organization**—In addition to the WSED division, IDA has a Research & Engineering Support Div., an Economic & Political Studies group, a Communications Div. and the Jason Div. The R&E Support group conducts studies for the Director of DDR&E and consists of "elder scientific statesmen." These groups also conduct operations research and systems analysis for other components of DOD and, to a lesser extent, other Federal government agencies. ■

Weapons-Effects Study Weak Link in Treaty Safeguards

UNDERGROUND testing to gain information on effects on nuclear weapons remains the only "soft spot" in the U.S. program of safeguards under the nuclear test ban treaty.

Sen. John Stennis (D-Miss.) told the Senate that the Preparedness Investigating Subcommittee has found that the area of testing to see what large nuclear explosions will do to U.S. weapons has not been pursued as vigorously as has the area of underground testing directed to the development of nuclear weapons.

The Preparedness Subcommittee last year reported to the Senate that the greatest disadvantage to the defense effort resulting from the treaty would be the impairment of the U.S. testing for weapons effects. This conclusion was drawn after testimony from top defense officials and scientists (M/R Sept. 16, 1963, p. 16).

Stennis disclosed that there have been some tests which involved weapons-effects experiments, but that this phase of the safeguards has been most difficult and the slowest in getting started.

Sen. Strom Thurmond (R-S. C.) said the Dept. of Defense has not completed the personnel reorganization and staffing which it expects will expedite weapons-effects testing. Stennis added that some progress has been made and "it is believed that the effort will continue."

"By and large, although a few soft spots are evident, the safeguards implementation program carried out in Fiscal Year 1964 and planned for Fiscal Year 1965 appears to be extensive, vigorous and effective," Stennis said.

Nevertheless, GOP presidential nominee Barry Goldwater is expected to make the matter a campaign issue.

Use of Drugs and Servos Urged to Aid Astronauts

Soviets discuss lunar bases for first time in public; organization elects JPL's Pickering as new president

by William Beller

WARSAW—Although man is the most fragile component in any system designed to explore the Moon and planets, scientists are suggesting improving his durability by drugs and his strength by servo linkages.

No one is arguing, however, that there is any competition between man and machine. Machines can take over as much of the exploration work as man's cleverness will allow them to do, with man at all times acting as monitor of the system and interpreter of data.

These were among the major conclusions reached at the Fifteenth Congress of the International Astronautical Federation, held here earlier this month.

Before the Congress adjourned, it elected Dr. William H. Pickering, director of Jet Propulsion Laboratory, its new president and agreed to hold its 1965 meeting in Athens.

Adrenalin and cardiac glicozides are said to be among the drugs effective in increasing a human's resistance to high-g loadings. A Soviet scientist reading a paper by the well-known physiologist V. V. Parin, medical consultant to the Russian cosmonauts, described experiments in which these drugs were used on human subjects under nine-g loadings.

The author said that measurements of their physiological responses showed a heightened capacity to withstand relatively high accelerations.

● **Extra muscles**—A start has been made in giving man within himself the strength of a multi-horsepower machine, but at the same time retaining in man his flexibility and right to change his mind. These abilities probably would be needed most if astronauts have to make some manual adjustments while under heavy loads of high accelerations.

In this regard, W. H. Helvey, bioastronautics chief at Lockheed Missiles & Space Co., described a myoelectric servo boost system which at its present stage can provide power assist to a subject's arm. The power comes from a motor and the strength from a flexible mechanical frame in which the subject's arm lies. The signals emanate from the straining of the arm muscles. The myoelectric servo boost so far provides power assist only for arm motion in one plane.

Although the goal is complex motions in three planes, a Spacelabs, Inc., motion picture illustrating the company's development and shown by Helvey had subjects outfitted with the system performing actions such as lifting, tracking, maneuvering and displacing.

The need to improve man and particularly to put him in the job that suits him best was asserted by Dr. Charles S. Draper, head of MIT's Instrumentation Lab. Classing the problem as one "amenable to solution by conventional engineering criteria," he took the example of the part man plays in guidance and control tasks.

Man's role here can be evaluated "considering such factors as size, weight, power, bandwidth, versatility, reliability and cost in relation to the mission requirements. . . ."

To perform such an engineering analysis, "the realistic aspect of the underlying engineering characteristics of the man as well as the unmanned component must be evaluated," said Draper.

● **Apollo guidance praised**—Earlier, Draper told MISSILES AND ROCKETS that the guidance system for *Apollo* is a general unit that with only a few minor changes in the computer would be able to lead astronauts "even to the stars."

Unlike missile guidance systems, into which the country has poured money as into a "rathole," the *Apollo* system "is self-contained and complete," Draper said.

With respect to space systems, Draper concluded in his paper to the Congress that the optimum system for extended operations "should be basically automatic and able to perform without help from remote equipment." He said it should also have provisions for onboard monitoring and optional operation by human pilots. Furthermore, for purposes of information exchange, "the system should include provisions for the roles to be played by man and for radio and radar links with ground-based installations."

● **LIL interest**—The question of machines also came up for discussion during a symposium on the *Lunar International Laboratory (LIL)*.

The best answer was said to be one leading to getting the most data from the Moon at the least cost in men and money.

The concept of *LIL*, first expressed at an IAF meeting two years ago, is to get the cooperation of all nations in setting up a laboratory on the Moon. The mechanisms for doing this and its financing were studiously avoided by the participants in the *LIL* symposium in the recent IAF conference. They maintained that they were speaking not as representatives of any organization, but simply as private scientists, educators, engineers and attorneys.

Nevertheless, it was pointed out that in such a way other international enterprises of value have been started. Named were the C.E.R.N. International Computing Center in Geneva, ELDO, ESRO and the IGY. With respect to *LIL*, the participants agreed such a laboratory could be set up and operating in the decade starting in 1975.

The bases needed by men living on the Moon were described by a Soviet architect. This marked, according to several participants, the first time a Soviet representative had discussed such an enterprise in an open conference.

The Soviet architect stressed the need to use the physical and chemical properties of the lunar soil for reconstruction purposes rather than attempt to import materials from Earth. He also held out the possibility of using the modules sent up from Earth as a form of housing.

Questioned after his talk about the date the Soviets had in mind for a lunar landing, the architect would not comment. However, L. I. Sedov, head of the Soviet Commission on the Exploration and Uses of Outer Space, said—seemingly facetiously—at a banquet a few nights after the *LIL* symposium, "when we tell people we can land on the Moon by 1971, they say to us 'why so long, what is holding you up?' " ■

NASA Speeds to Fill Gap In Availability of Big Telescopes

by Hal Taylor

THE U.S. GOVERNMENT is moving to fill the space exploration gap created by the lack of adequate ground observatory capability.

NASA is currently negotiating with the University of Texas for development of a new 80-to-150-in. telescope for the school's McDonald Observatory. This would be one of the five largest reflecting scopes in the world.

At the same time, the National Science Foundation is proceeding with the development of a 60-in. telescope to be located in Chile.

In addition, space agency officials say, proposals for other telescopes have been received from several other universities and groups.

Noting that the agency had funded a 60-in. telescope at the University of Arizona two years ago, one official said "we have done this sort of thing before and we will probably do more in the future."

The government activity in the ground observation field results from the fact that use of existing observatories has reached the saturation point at the same time that the space program's need for additional study of the Moon and planets is growing.

● **Cause disputed**—Dr. Martin Schwarzschild, director of Princeton University's astronomy department, told MISSILES AND ROCKETS it is very difficult to get viewing opportunities on telescopes above 40 inches any more.

"There has never been a time that the 100-in. telescope at the Mt. Wilson observatory has not been completely booked up," he declared.

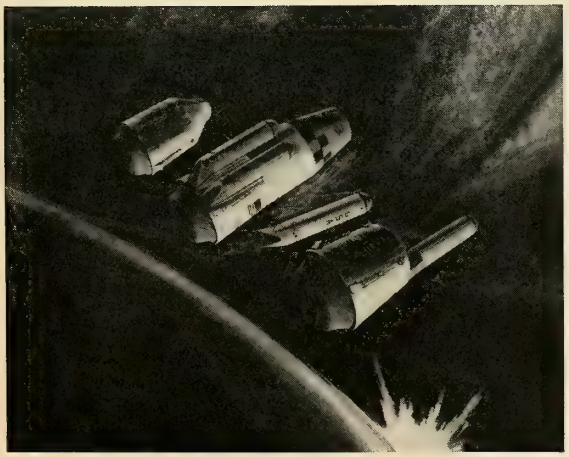
A NASA official said that one roadblock to the development of new telescopes is the lack of trained astronomers.

Schwarzschild, however, disputed that statement. He said that there is no question but that there is more manpower available than viewing capability. But he admitted that there is a manpower shortage in terms of getting top astronomers to take positions as heads of astronomy departments.

NASA officials refused to reveal any details of the proposals which it has received, including the possible size of the University of Texas's telescope. They said it would be imprudent to discuss the matter while it was being negotiated. Informed sources said that the telescope would not be smaller than 80 in. and might be as large as 150 in.

A NASA spokesman said another reason for the agency's hesitancy to discuss specifics is that while it is interested in further ground-based observation of the Moon and planets, it has not yet defined the scope of that interest or received approval from top officials to undertake the program.

The observatory in Chile is directed by the National Astronomical Observatory. The Air Force previously provided funds for a 36-in. scope. Approval of NSF funding of the 60-in. scope was included in its FY '65 budget. ■





Versatile Douglas Space Vehicle Concept Shown at IAF

ALL-PURPOSE space vehicle proposed by engineer Phil Bono, of Douglas Aircraft Co.'s Missile & Space Systems Div. and described at Warsaw IAF meeting is shown in artist's conceptions. At left, vehicle is refueled in Earth orbit by tankers which will return to Earth. At right, retro engines are fired near lunar surface for direct landing without orbital maneuver. Vehicle would carry as many as eight strap-on LH_2 tanks, which could be ejected when empty or used as shelters on Moon.

Congressional Rein on R&D Defended

Economic impact of programs dictates strict selectivity; 6,000 hear more than 140 papers on electronics, contracting and procurement

by Charles D. LaFond

CONGRESSIONAL SCRUTINY of national R&D activities, particularly of methods and objectives, is both essential and healthy. In fact, said Rep. Melvin Price (D-Ill.) speaking before the Eighth Annual Military Electronics Conference (MIL-E-CON 8) in Washington, industry should consider it an opportunity, not a calamity.

Pointing out that this year's $15-billion Federally supported R&D program represents the largest single government enterprise (15% of the total U.S. budget), Price asserted that the nation can no longer afford to support undesirable programs.

Four principles, he stated, should be established as points of concern by Congress for the study or re-examination of Federal R&D activities: clear-cut program objectives; realistic total cost estimates; existence of centralized responsibility and management continuity; and a plan to make use of R&D results.

Too often in recent years, said Price, millions of R&D dollars have resulted only in program abandonment with few useful results to show for expenditures.

Some waste can be expected, he said, by the very nature of R&D, but there is need for grave concern when the cause of such waste is inadequately defined program objectives.

Price cited the now dead *Pluto* nuclear ramjet and the nuclear-powered aircraft R&D programs as typical examples of poorly invested U.S. funds.

"The most serious and foolish waste," of all, said Price, is the failure to put new technology to use after spending millions to complete a successful R&D effort. The SNAP-10A program is typical, he said, except that in this instance Congressional pressure was sufficient to save it and result in an Executive decision to continue with the flight-test program.

● **Meeting well attended**—Despite the national trend toward reduced attendance at technical meetings, MIL-E-CON 8 matched last year's registration of over 6,000 and also topped all previous years in number of exhibits.

Over 85 industrial and 10 military/government displays filled the Shoreham Hotel's exhibit area. One entire aisle in the hall was filled with Canadian industry displays.

The only major criticism of this year's three-day meeting was that it should have been longer. Many attendees and contributors at the technical sessions, said Mrs. Harriett H. Manley, registration and arrangements chairman, felt that the 10-to-12-minute paper presentation time limit was too short and that the following free discussion periods were too limited.

● **Paper highlights**—Over 140 invited and contributed technical papers were presented at 19 sessions. The presentations spanned the entire field of military electronics systems and techniques and included several sessions on current Dept. of Defense contracting and procurement philosophies.

Describing DOD's present use of the Project Definition Phase in R&D contracting, J. W. Roach, assistant director DDR&E for engineering management, pictured the approach as a "filter." It is, he said, a tool which effectively screens major system proposals.

Through such analyses, he pointed out, both inter- and intra-system operational effectiveness, technical approach, and life-cycle cost can be determined. In addition, PDP assures that later proposals for follow-on work are at the engineering stage—not requiring experimentation.

"Incentive Fee Contracting," a paper presented by W. W. Storey, a Martin Company vice president, extolled the savings already achieved by the Department of Defense using such contract clauses. Ten cents on each DOD contract dollar has been saved, Storey claimed, through cost-plus-incentive-fee and fixed-price methods.

Because either reward or penalty is involved, he stated, contractors have been forced to better plan and execute contracts. The results of this, suggested the author, is a superior product at lower total cost.

He cautioned, however, that fixed-price contracts are still most desirable and should normally be favored over all other contracting approaches whenever the program can be clearly defined.

● **ComSat use described**—J. R. Rae of American Telephone and Telegraph Co. presented his views of the "Prospective Use of Satellite Communications by the Bell System." At the present stage of development, he stressed, communications satellite use within the continental U.S., Canada, or Mexico are not economically feasible. The system initially would be for providing telecommunications links overseas at distances beyond 1,000 mi. (And, he pointed out, for overseas circuits Bell is limited to telephone operation only.)

Bell will lease from the ComSat Corp. sufficient usage of its *Early Bird* HS-303 satellite to provide 100 circuits between the U.S. and Europe.

Once an operational satellite system exists, Rae stated, Bell would use it along with all of its other facilities to provide operating flexibility. The qualification, however, said Rae, is that Bell's overseas correspondents agree and that circuits via satellite show costs comparable to those of currently available facilities.

● **NASA comsats**—NASA's *Advanced Technological Satellites* will be used for many space applications, including the testing of future satellite communications systems and techniques. *Syncom III*, according to J. J. Dougherty, assistant director of NASA's communications and navigation programs division, will complete the space agency's experimental program to demonstrate feasibility of communications satellites. ■



The rope trick...and the vanishing submarine

Hovering over ocean waters, the Boeing Vertol 107 helicopter will be able to play a deadly game of "hunt and kill" with enemy submarines. Down through the hatch, a sonar ball is lowered by winch and cable into the water. Two sonar operators, in a sound-proof, air-conditioned unit, monitor their instruments and listen.

Contact! The helicopter closes in, firing torpedos or dropping a depth charge. With a thunderous explosion, a huge geyser erupts from the ocean, and the sub vanishes . . . forever.

For ASW requirements, the Boeing Vertol 107 comes with quick attachment provisions. If electronic maintenance is required, the module can be quickly replaced—so there's less helicopter downtime. Because the 107's tandem configuration results in low downwash, there's minimum underwater noise, better sonar operation. Optional long range fuel tanks permit more than 4 hours "on station."

Highly versatile, the Vertol 107 helicopter may also be used for inter-ship transfer, fleet replenishment, carrier guard duty, minesweeping (when equipped with mine countermeasure modules), and search and rescue missions. The 107's sealed-in fuselage gives it a water landing capability that is a key advantage in operations of this type. This tremendous versatility is the product of creative engineering, forward thinking weapons system program management, and the vast resources of The Boeing Company.

BOEING
VERTOL DIVISION
MORTON, PENNSYLVANIA

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SUBROC—is the most potent antisubmarine weapon in existence today. SUBROC travels farther and faster than any other tactical weapon carried by submarines.

The Goodyear Aerospace Corporation, as prime contractor for the Bureau of Naval Weapons, developed this underwater-air-underwater missile.

The weapon system was conceived by the Naval Ordnance Laboratory, who also served as technical director for the development program.

Goodyear Aerospace created a management orgar tion which is really a company within a company SUBROC. This GAC Division directed the entire in trial team effort, and the design of major element the weapon system including the rocket engine, g ance, auxiliary power unit, fire control and telem systems. Additionally, Goodyear manufactures cor



hunter"a"killer"

, structures, and test equipment for the weapon erforms the assembly and checkout.
th plants in Akron, Ohio, and Litchfield Park, Arizona, ur broad spectrum of capabilities, GAC is uniquely ied to further other aerospace projects.
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Is it fish or foul play?

Sorting out real target information from the rest of its watery environment is one of the most complex problems of antisubmarine warfare.

This year ITT was named systems manager for the new Atlantic Undersea Test and Evaluation Center (AUTEC) that will be the principal U.S. Navy facility for checking out ASW weapons systems. AUTEC will be an "inner space" range, the first capable of precision tracking in an underwater atmosphere of great distance and depth.

Soon the whole range of ASW problems—detection, classification, pinpointing and destruction—will be examined in a controlled, yet authentic, marine environment.

AUTEC will be 100 miles long, 20 miles wide and 6,000 feet deep. ITT will lace this ocean area with hydrophones and other sensitive instruments, erect tracking gear to permit thorough underwater evaluation of such advanced ASW weapons as SUBROC and ASROC.

ASW is not new to ITT. World War II's HUFF-DUFF system that pinpointed U-boat radio transmissions, no matter how brief, was an ITT development.

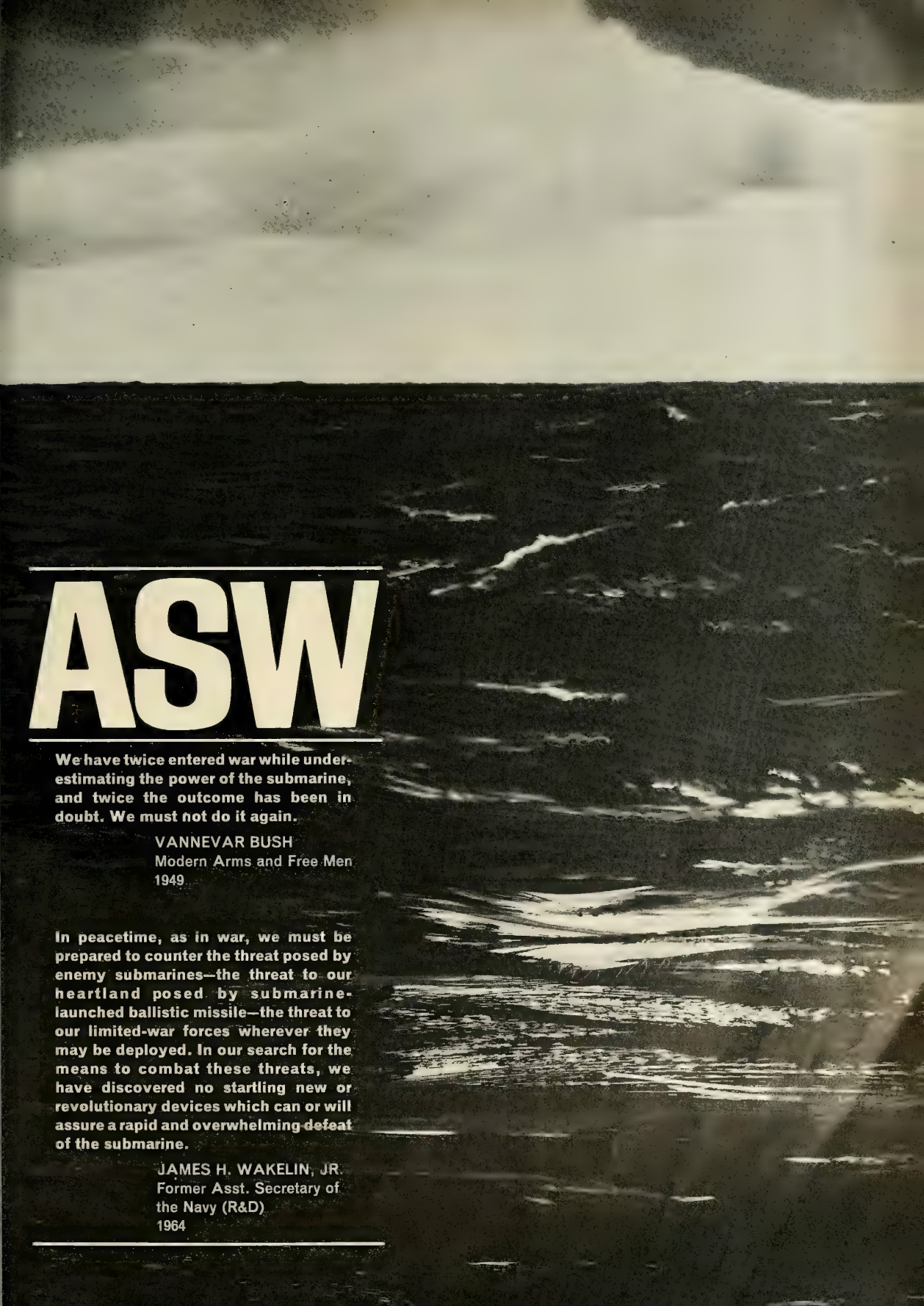
In 1957, after solving the problem of high density storage of multichannel analog information, ITT developed equipment to record underwater acoustical environments. Now, ITT sonar simulators using tapes of actual conditions can train up to 10 sonarmen at once.

Currently, ITT is developing DINAH, an advanced underwater detection system based on electro-magnetic principles.

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ITT



ASW

We have twice entered war while underestimating the power of the submarine, and twice the outcome has been in doubt. We must not do it again.

VANNEVAR BUSH
Modern Arms and Free Men
1949

In peacetime, as in war, we must be prepared to counter the threat posed by enemy submarines—the threat to our heartland posed by submarine-launched ballistic missile—the threat to our limited-war forces wherever they may be deployed. In our search for the means to combat these threats, we have discovered no startling new or revolutionary devices which can or will assure a rapid and overwhelming defeat of the submarine.

JAMES H. WAKELIN, JR.
Former Asst. Secretary of the Navy (R&D)
1964

asw special report

Navy Feels Defense Adequate—for Now

But situation fraught with uncertainties could worsen if Russia elected to build high-quality nuclear boats; Secretary Nitze calls ASW program 'important missing component' in U.S. security

FIFTEEN YEARS and several generations of technology separate the two statements in the frontispiece to this report—and yet the threat implied in the second is as mortal as that recalled by Dr. Bush's comment on the two World Wars.

Has the Navy actually retrogressed in the conduct of anti-submarine warfare? How effective is present equipment in detecting, classifying, localizing and destroying enemy submarines? What exactly, is the threat? And how serious is it? Why has the Navy found it necessary to create a directorate of anti-submarine warfare and an ASW systems project? What of the future?

These are some of the questions to which this special report is addressed. And, although military security hangs over all aspects of ASW like fog over the Grand Banks—obscuring and distorting—it is possible to penetrate this mist to arrive at significant and important conclusions.

For example, defense against the threat to the United States posed by submarines is generally divided into three separate categories—protection of the U.S. from submarine-launched ballistic missiles (SLBM), protection of merchant shipping and protection of the naval fleet. However, the relative importance, or seriousness, of any one of these threats depends on U.S. strategic conceptions, the capability and adequacy of U.S. forces, Soviet submarine forces and the Russian philosophy for the employment of those forces in war.

Further complicating the ASW picture are such interlocking factors as geography, relationships with other free-world forces, the proliferation of submarine fleets, and ignorance of the ocean environment.

● **The play's the thing**—Secretary of the Navy Paul H. Nitze feels that "the important missing component in having an answer to the Soviet threat to the continental United States is the Navy's ASW program. . . ."

The House Committee on Appropriations submitting its report on the FY '65 Defense bill stressed that of the three threats "the most difficult field is the protection of the continental United States against submarine-launched missiles." In a pessimistic note, the committee added that "it may be that naval vessels, weapons and equipment will never be able to adequately defend the country against this threat."

An essential, though unstated, factor behind these views is U.S. strategy for the conduct of a strategic nuclear war.

As with all strategic concepts, if the premises are accepted so are the consequences—one of which is coping with the SLBM counter-threat. Currently, U.S. strategy is based on assured destruction and on damage limitation.

In the scenario for such a war, Navy forces figure prominently in a damage-limiting role. For, while Soviet missile-firing submarines are inadequate to win military victory, they would be capable "of wreaking unacceptable urban-industrial damage on the United States," in Nitze's words. Location and destruction of these submarines, therefore, takes on more importance than it would under "countervalue" or "finite deterrence" or other nuclear war strategies.

Accepting the prudence of a damage limiting strategy does not, however, answer the crucial question: How serious is the SLBM threat? Secretary of Defense Robert S. McNamara estimated that the Soviets have 142 missiles with ranges of less than 500 mi. aboard

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Washington, D.C. 20005

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CARRIER, helicopter and destroyer—together with hunter-killer submarine—form the ASW team.

submarines. All of these missiles must be fired from the surface. In fact, one source told MISSILES AND ROCKETS, there is "no evidence, classified or unclassified," that the Soviets have yet fired a missile from a submerged submarine.

The missiles aboard Soviet submarines consist of both cruise and ballistic weapons. The ballistic weapons are liquid-propelled and have a range of 350 mi. Three are carried in the conning-tower superstructure. The 142 missiles cited by McNamara are estimated to be distributed among 30 submarines—only a small number of which are nuclear-powered.

Assuming these figures to be correct, it would not be easy for the Soviet Union to mount a ballistic missile attack on the U.S., according to Navy officials.

One high-ranking officer who has spent his career in ASW told M/R that "in my personal opinion, employment of ballistic missile submarines in a surprise attack would be very difficult for the Soviets to bring off. The very presence of these submarines is suspicious." Furthermore, the warning time that the U.S. would get of the debouching of such a force could be as much as two weeks.

Asked about the effect on this evaluation of Soviet development of a submarine-launched missile of *Polaris* range, this officer observed that at some range, after all, the problem ceases to be one of ASW and becomes one of ballistic missile defense.

● **Convoy and fleet defense**—Protection of merchantment and war-material convoys on the high seas is a traditional, and essential, mission of naval power. The threat against such shipping is ranked second only to the SLBM threat to the national territory.

There are, however, several mitigating factors, which, Navy officials feel, reduce this problem to manageable proportions.

First, the United States in such operations can rely not only on its own ASW forces, but also on allied ships and planes. As Adm. Charles E. Weakley, Commander of ASW Forces, U.S. Atlantic Fleet, explained it, "the littoral is in friendly hands and, therefore, the Atlantic unites the allies. NATO then can aid in coping with the problem and the addition it makes to our total capability is very significant."

Another factor favoring the U.S. is geography. The Soviets are limited to three ports (Vladivostok, Petropatlovsk and Murmansk) with direct access to the oceans. Still another advantage is the ability to route ships along paths favorable to the defense and unfavorable to the submarine. The importance of this can not be overemphasized, although again this is a highly classified subject. With new bottom-bounce sonar techniques, a convoy routed across the ocean along a path well-mapped by the Navy will allow maximum detection ranges to be obtained against submarines.

With bottom-bounce sonar, submarines as far away as 100 mi. from a convoy can be detected. With convergent zone methods, detection can be accomplished when the submarine is as far away as 33 mi. Stand-off weapons can then be used to kill the sub before it gets into firing position.

"The problem in convoy operations," a Navy official says, "is to 'sanitize' and defend a moving area of the ocean." In this, he adds, convoy protection is closely allied to defense of the fleet. However, he says, fleet protection is the toughest of the three areas of defense since an enemy submarine need only avoid contact with defensive forces until it is ready to attack.

Another problem in a limited-war situation is identification, as friend or foe, of submarines. Although techniques are being developed to photograph contacts, either with laser cameras or dunked cameras, it is necessary now "to ask the submarine to identify itself." Or, as another Navy officer put it, "we know where our submarines are and if we don't have one in the area of the contact, we assume it is an enemy and destroy it."

● **Limited war script**—In a provocative and illuminating speech to a Joint Session of the National War College

and the Industrial College of the Armed Forces, Secretary Nitze has postulated a limited-war scenario—in which a war of attrition is conducted at sea while the shore is a sanctuary to both sides.

"Such a war," he declared, "would bring the entire spectrum of our ASW forces into play against the one weapon that could be used against us most effectively—the submarine. Our SSN's, our mining forces and patrol aircraft squadrons would have to exact attrition from transiting submarines."

In this "concept of usable power" the importance of non-nuclear weapons is self-evident. For this reason, the Navy is emphasizing conventional warheads within its ASW arsenal.

• **Soviet sub fleet**—Even against this background, the Soviet submarine fleet remains a serious problem for the Free World.

The Soviets have almost four times as many subs as the U.S. (The Germans at the start of World War II had only 57 and, at the end of the war, the U-boat force totalled 336.) To this sheer force of numbers must be added the fact that the initiative lies with the Soviet Union. And the danger is further intensified by the true submersible character and high underwater speed of the nuclear submarine.

Of the estimated 420 submarines operational in the Soviet Navy, 321 are ocean-going, long-range, conventional and nuclear submarines. About 25 are nuclear boats—both attack (10) and ballistic-missile (15) submarines. The remainder are short-range, coastal-defense boats with small displacement, which are operational in the Baltic and the Black seas. These are being retired at a faster rate than new submarines are being built with a consequent shrinking of the absolute value of the submarine force.

The characteristics of Soviet ocean-going submarines are by class:

—*Z class:* Built since 1956, these are the most modern conventional subs

NAVY ASW SURVEILLANCE AND OCEAN PATROL FORCES

AIRCRAFT CARRIERS: Nine Essex carriers (CVS) are in the fleet as platforms for ASW aircraft. These ships, according to the Navy, "have the speed, range and space required for all ASW weapons systems now current or likely to be developed in the next few years." Later Essex ships will replace older models as Forrestal class attack carriers are introduced into the fleet. At least one carrier has been equipped with a large sonar. Aircraft carriers are the backbone of the hunter-killer group.

ATTACK SUBMARINES: One-hundred and three submarines, including 23 nuclear-powered craft, were in the fleet at the end of Fiscal 1964. The Navy is building nuclear attack submarines at a rate of six per year and expects to have more than half of its underwater fleet nuclear-powered by FY '69. Total force will remain relatively constant throughout this period. Modernization program for World War II submarines has been halted since it is felt that even the modernized subs are ineffective against nuclear-powered submersibles.

DESTROYER ESCORTS: Twenty-three destroyer escorts are currently in the fleet. Increase of 16 new ships is part of the '65 construction program. Specifically designed as ASW ships, DE's are used for HUK, coastal patrol or convoy escort. Equipment includes bow-mounted sonar (in the newest), variable depth sonar, DASH, *Asroc* and anti-submarine torpedoes.

DESTROYERS: One-hundred and ninety-five other destroyer types, both multi-purpose and ASW ship; some previously slated for retirement will be retained for use as ASW ships. FRAM program is significantly boosting the ASW capability of these ships. Seventy-nine Gearing-710 class destroyers have been modernized with the addition of a hull-mounted sonar, an *Asroc* launcher, two torpedo launchers and DASH. Conversion of 18 Forest Sherman class destroyers is continuing with the second increment planned this year. DASH is the primary ASW capability being added to this class. Addition of an *Asroc* launcher to Mitscher class frigates, begun last year, is continuing.

PATROL AIRCRAFT: Consists of both carrier-based and land-based aircraft. Grumman S-2D, E and F fixed-wing Tracker and the Sikorsky SH-3A helicopter are the backbone of the carrier forces. Eighteen squadrons of Trackers are in operation and nine squadrons of the SH-3A. Long-range, land-based patrol aircraft include: Lockheed's P3V Orion, which is rapidly replacing the older Lockheed P-2 Neptune; SP-5 Marlin seaplane squadrons are being phased out. There were 30 land-based squadrons at the beginning of this Fiscal Year but these will be reduced by one with the retirement of an SP-5 squadron. Capabilities of the aircraft are listed below.

S-2 TRACKER: Basic aircraft has been under procurement for eight years. Navy expects the final buy in Fiscal '66. D and E procurements complete, F model now being bought. Squadron consists of 10-12 aircraft. F model has new display equipment, increased range and endurance, and additional sonobuoy capability. Carrying a four-man crew, the S-2 has a 7½-hr. patrol capability with an average range of 230 mi. Take-off weight is 26,641 lbs. An internal bomb bay carries two torpedoes while three external stations can carry additional ordnance. Navy terms this a very good magnetic detection aircraft.

SH-3A, SEA KING: An all-weather, gas turbine helicopter with a speed of 148 mph and a range of over 500 mi. (operating radius 250). Gross weight is 17,768 lbs, with a payload of 6,574 lbs. It carries a dipping sonar, which can reach below the thermal layer, and internally stored torpedoes. Navigation is being improved for night operations and the short-pulse, ASPECT classification equipment is being added to the Sea King. Fourteen helicopters normally constitute a squadron.

P-3A ORION: First scheduled deployment of this aircraft was made in May, 1963, and it is an important addition to ASW patrol forces. Able to fly at speeds up to 435 mph, it can then loiter in the area of 170 mph. Search capability is placed at 280,000 sq. n. mi. Endurance is 13.2 hours on four engines and 17.7 hours on two. ASW ordnance weighing 1,848 lbs. can be carried, including torpedoes, wing-mounted rockets and depth charges. It can carry 15 lightweight or seven heavyweight mines. More than 5,000 lbs. of detection gear can be carried. Four squadrons are now operational. Carries Julie and Jezebel sonobuoys. Plane is strengthened and modified version of the Lockheed Electra.

SP-2E AND -2H, NEPTUNE: Mainstay of the land-based patrol aircraft, it is being replaced by the Orion. This aircraft has a range of 3,685 mi. a take-off weight of 79,788 lbs., a speed of 181 knots and a loiter speed of 158 knots. In addition to patrol operations, the plane can be used for mine laying or torpedo missions. Over 20 squadrons are still in the active inventory and it will be 1970, at present deployment rates, before the Neptune is completely replaced by Orion.

in the Soviet arsenal. They have a range of over 20,000 mi., a surface speed of 20 knots and a submerged speed of 15 knots. Overall length is 290 ft., with a submerged displacement of 2,600 tons. About 26 of these boats were built before the shift to the nuclear submarine. The Z class has high-capacity batteries for power.

—*W class:* Built between 1950-1955, this class constitutes the bulk of the Soviet sub fleet. Two-hundred and ten are operational. They have a displacement of 1,000 tons, a length of 245 ft., and a range of 12,000 mi. Surface speed is 16 knots and submerged speed is 13 knots. The class is patterned after the German Type XXI.

Several modifications of these two classes exist for specialized missions. For example, a small number of Z and W class boats have been modified for submarine hunter-killer operations and a larger number as ballistic missile launch platforms.

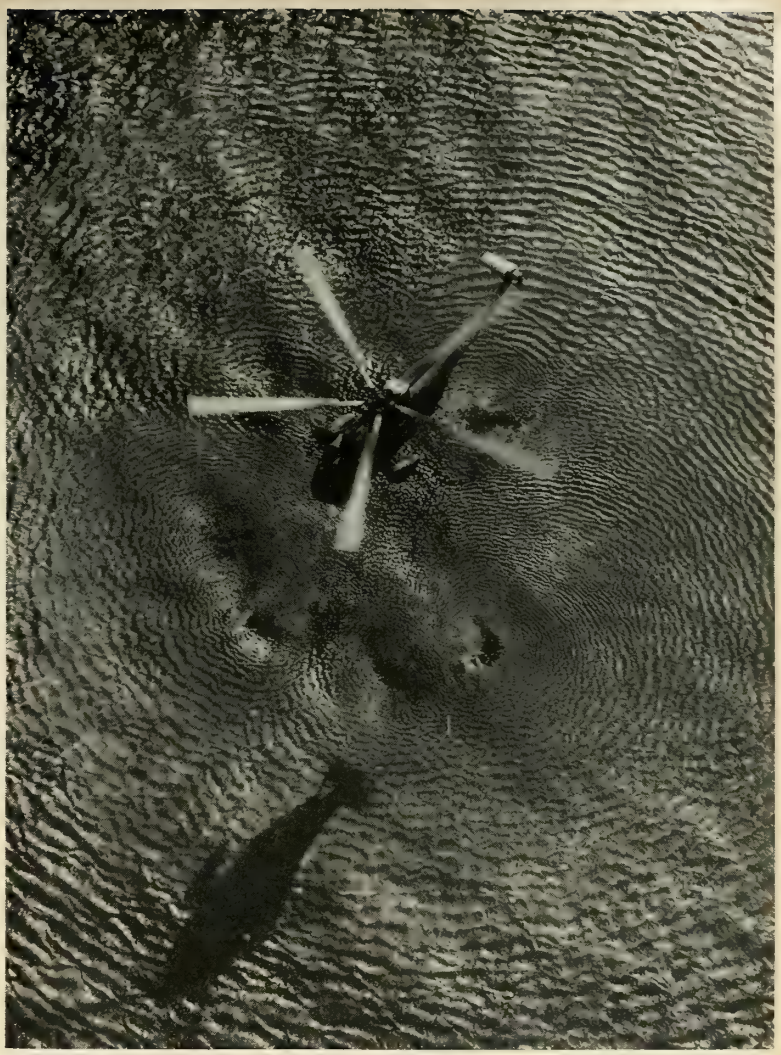
● **Four fleets**—The Soviet submarine force is divided into four fleets: Baltic, Black Sea, Arctic and Pacific. The first two fleets are almost exclusively coastal-defense and have 70 and 50 submarines respectively. The Arctic fleet consists of 150 submarines operating from Murmansk/Archangel, and the 120-boat Pacific fleet is based at Petropavlovsk and Vladivostok.

Twice before the Soviet Union has built huge submarine fleets and failed to use them. In World War I, the Soviets built 120 coastal defense boats, comparable to the U.S. "R" type, only to scuttle all but one, which escaped to Finland after the Communist revolutionary government negotiated a separate peace with the Germans. In World War II, the Russians had 237 submarines operational in 1939 and 70 more on the ways. This was more than the rest of the world put together. But, again, this force was not employed to any great degree.

Even now, according to a Navy admiral, the Soviet mentality is still defensive and is based on the protection of the motherland. This is in spite of a big, modern fleet. "They have made several long excursions," he adds, "but they are not doing it as a matter of regular, routine operations."

As nuclear submarines are phased into Soviet forces—at an estimated rate of 5-6 per year—the Russians have been giving their older boats to satellite nations. This presents a real problem since, as with proliferation of nuclear weapons, an "nth" country sub attack on one of the capital ships of the two major powers could have an escalating effect.

Among the nations now possessing Soviet submarines, China is the biggest threat. It is estimated that the Chinese Communists have 31 submarines—including 17 W class boats. In addition, before the Sino-Soviet rift, the Russians provided equipment and know-how for construction of W submarines.



SIKORSKY SH-3A Sea King helicopter uses dipping sonar to increase range.

Other nations with Soviet submarines are: Albania (4) and Indonesia (20). Satellite countries bordering on the Baltic or Black seas also have small numbers of subs for coastal defense.

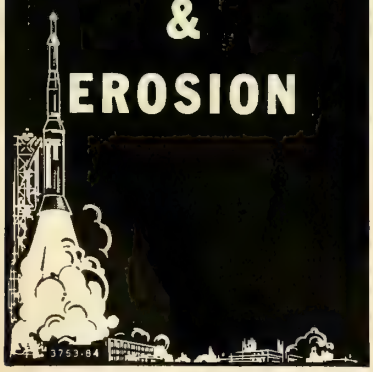
● **The big question**—Both Navy and industry officials interviewed by M/R feel that the conventional threat represented by the Z- and W-class submarines is well in hand. This is not to say that damage would not be inflicted on U.S. forces; it is to say, however, that in a war of attrition the Soviet submarine force would suffer at an unsustainable rate over a comparatively short period of time.

● **Nuclear complications**—What concerns U.S. defense planners is the Soviet nuclear fleet. These submarines are true submersibles with unlimited range and submerged speeds of 30 knots at depths of 500-600 ft.

The Soviet nuclear ballistic missile submarine consists of the early E class with a submerged speed of 22 knots and a displacement of 5,600 tons. It has six missile tubes, two abreast on a flush deck. There are six of these boats in the Pacific.

The later H class has a submerged speed of 30 knots and a displacement of 3,500 tons with the same six missile tubes. Nine are operational and on station. In the nuclear attack class of submarines the Soviets have an estimated 10 operational with a submerged speed of 30 knots and a displacement of 3,000 tons. There are six bow torpedo tubes on the SSN.

This is a formidable weapon—but it has a mortal defect.

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The Soviet nuclear submarine is noisy. This, coupled with U.S. quantum improvements in sonar and a truly major ship silencing program, rob the Russian craft of some of the advantages of nuclear power. One high Navy official compares the Soviet submarine to U.S. battery boats in terms of noise; he adds that "to be quiet, it has to go at battery boat speed."

However, how many of these "first-try" submarines will be built is a major unanswered question and one that cannot be ignored. Historically, the Soviets have settled on one class of submarines and then built several hundred of them. If this pattern holds true, the problem will not be too serious. However, if the Soviets develop and build nuclear submarines of the quality of U.S. boats—with major emphasis on ship silencing—the threat would become one of the most serious facing the country.

● **U.S. capabilities**—The chart accompanying this article shows a partial analysis of the forces arrayed against the Soviet submarine fleet. To this must be added NATO ASW forces, which would swell U.S. Atlantic forces from over 40 ships and 500 aircraft to at least twice that number.

More important are the command and control elements which increase the flexibility and usefulness of these forces. ASW Atlantic Forces operate under central direction from Headquarters in Norfolk, Va., but with decentralized control of individual units of the force. Further, although the Atlantic is divided into sectors, there are no boundaries in the sea—units can be shifted from control of one sector to another quickly. This allows one sector to be in a high state of readiness while other sectors are conducting normal operations. The system was tested during the Cuban crisis in 1962 and held up very well.

In fact, Cuba provided the Navy with a unique opportunity to test its skills, equipment and tactics against some of the best of the Soviet's submarine arsenal.

"The results were highly gratifying," Adm. George Anderson told the House Armed Services Committee in 1963. "During the time of crisis, more than 20 submarine contacts were reported in the area of fleet operations or adjacent to the Cuban quarantine area. Some of these probably were false contacts, and quite a number were repeated contacts with the same target. We were able to identify six by photograph as Soviet submarines. . . .

"Anti-submarine warfare must be a team effort. Without question this was. These most recent experiences have attested dramatically to the capabilities of our air, surface, and undersea forces and our fixed installations to work together with maximum effectiveness."

Adm. Weakley explains the multiplying effect of centralized direction in terms of the fingers on the hand. "Properly coordinated, the hand acts as a lever to exceed the arithmetic possibilities of each finger taken individually."

● **Outstanding problems**—Again, in the words of the man who commands the Atlantic ASW forces, "We have come forward to beat hell since World War II, and we can do very well against Soviet conventional submarines."

Sonar ranges have increased several hundred percent since the war and, with the SQS-26 and the BOQ-2 sonars, another tremendous advance in detection range will have been achieved. As one experienced naval officer put it, "Today, if a ship is limited to ranges of 2,000 yards under good water conditions, someone starts checking on the equipment for a malfunction."

● **Unresolved**—However, major problems remain to limit the effectiveness of anti-submarine warfare. These include:

—Retention of personnel: Competition from industry has hindered the ASW effort. One Navy officer contends that he could increase the effectiveness of his forces severalfold if he could retain qualified people. "The re-up rate for sonarmen is extremely low," he says, "because the Navy gives them specialized training and then industry gobbles them up." A solution, being tried now, is to shorten the training time, giving a sonarman only operator training and, if he re-enlists, then giving him maintenance training.

—Ignorance of the environment: In the past, not enough attention has been paid to the physics of the ocean and the propagation of sound in this medium. Temperature, salinity, pressure and a variety of other factors determine the effectiveness of Navy detection equipment. With the advent of bottom-bounce and convergent zone equipment, the physics of the ocean takes on a new importance. Magnetic anomaly gear, as an illustration of how physical understanding helps tactical operations, will be increased in effectiveness as a result of the World Magnetic Survey, which mapped variations in the Earth's magnetic field.

—Tactics: The role of the nuclear attack submarine in ASW, the effect of stand-off weapons and longer-range detection equipment on HUK (Hunter-Killer) force composition and conduct of a non-nuclear war of attrition with shore sanctuary to both sides—these are but a few of the tactical problems which must be faced. ASW doctrine is classified, but at least one high-ranking Navy officer admits that tactical doctrine is lagging behind technology. ■



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HONEYWELL CERAMICS ADVANC



"BIG BENDER" is one of the most compact low-frequency sonar transducers ever built. Designed by Honeywell as a research sound source for the U. S. Navy Underwater Sound Laboratory, New London, Conn., this three-ton unit is made up of 90 bender bars, each of which uses 52 elements of Honeywell K-12 precision ceramics that are machined to within two-thousandths of an inch. The ceramic bender bars are able to withstand high internal stresses resulting from the large excursions necessary to produce a four-kilowatt output at 117 cycles per second. The "Big Bender" has an electroacoustic conversion efficiency of greater than 50 per cent and is capable of operating for one year at depths to 1000 feet. Similar Honeywell bender transducers operating at somewhat higher frequencies have shown efficiencies as high as 60 per cent.

ONAR TRANSDUCER TECHNOLOGY

High-efficiency ceramics extend the range and durability of sonar transducers

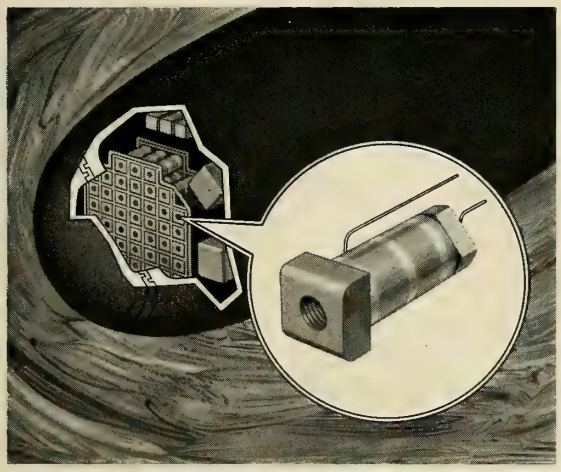
Through significant advances in underwater acoustic technology and high-efficiency ceramics, Honeywell has been able to design sonar transducers that provide lower frequencies, lower operating depths and higher power for some of the nation's most advanced underwater sound programs.

To meet these requirements, Honeywell is producing three types of ceramics that are now available to the industry:

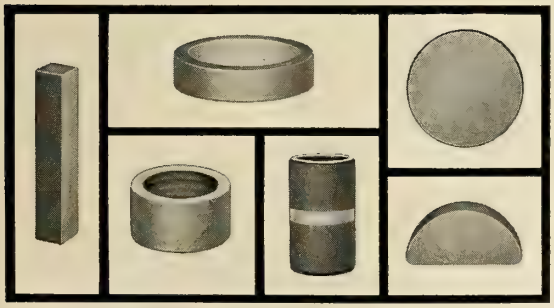
- Lead zirconate/titanate
- Modified lead zirconate/titanate
- Barium-titanate

This range of basic materials, coupled with Honeywell's unique capabilities in custom-building elements of various piezoelectric properties, provides a selection of *quality ceramics* that meets the demands of the most advanced sonar transducer designs.

Although it is common practice to test each ceramic element before it is included in a system, the quality of Honeywell ceramics is so consistently uniform that many customers use the sampling technique of testing. To achieve such quality, Honeywell maintains stringent control procedures throughout its ceramic manufacturing process. All ceramic materials meet IRE standards for electrical properties and are guaranteed to meet minimum standards. When the ceramic materials are processed, automated equipment controls and records the process. The result is uniform ceramics which permit sonar transducers to reliably meet design specifications at high power over long periods.



ADVANCED TRANSDUCERS FOR ASW VEHICLES are being developed and produced by Honeywell. The multi-element array shown is a highly directional transducer designed for use in a sonar projector-receiver system.



CERAMIC TRANSDUCERS of various shapes, sizes and characteristics have been brought to a high degree of development by Honeywell. Having a high rate of exact reproducibility of electrical and mechanical properties, these ceramic elements meet specifications for a variety of acoustic applications.

Honeywell transducers operate in all types of undersea conditions

The ultimate performance of a sonar system depends critically on its transducer, and a transducer is no more effective than its ability to meet system requirements in the prevailing acoustical conditions of a body of water.

At Honeywell, achieving the best combination for a particular application results from close cooperation between the transducer designer and the systems engineer who consider trade-offs such as bandwidth, efficiency, depth capability, and the electrical system parameters governing the performance of transmitters, receivers, and beam-forming and signal-processing networks.

During ten years of participation in the Navy's sonar programs, Honeywell has gained a thorough understanding of underwater acoustics, undersea warfare systems and sonar instrumentation. This has resulted in the design and production of a successful family of sound projectors and hydrophones including:

- Longitudinal vibrators
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- Flexing-beam projectors ("bender bars")
- Extensional-flexural elements and arrays
- Reference hydrophones

Each of these configurations requires ceramic materials of the highest uniformity and quality to meet the exacting demands of the particular application. As an example of the capabilities of the ceramics in its systems, Honeywell today produces transducers covering a range of frequencies from 45 cycles through several hundred kilocycles per second, acoustic power ratings of several kilowatts and operating-depth capabilities to the bottom of the deepest ocean trenches.

WE INVITE YOUR REQUEST for further information on Honeywell ceramics or sonar transducers. Please specify your interest by writing on your letterhead to Honeywell, M.S. 847, 600 Second Street North, Hopkins, Minnesota 55343.

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Hostile underwater missile sites are murderously hard to find

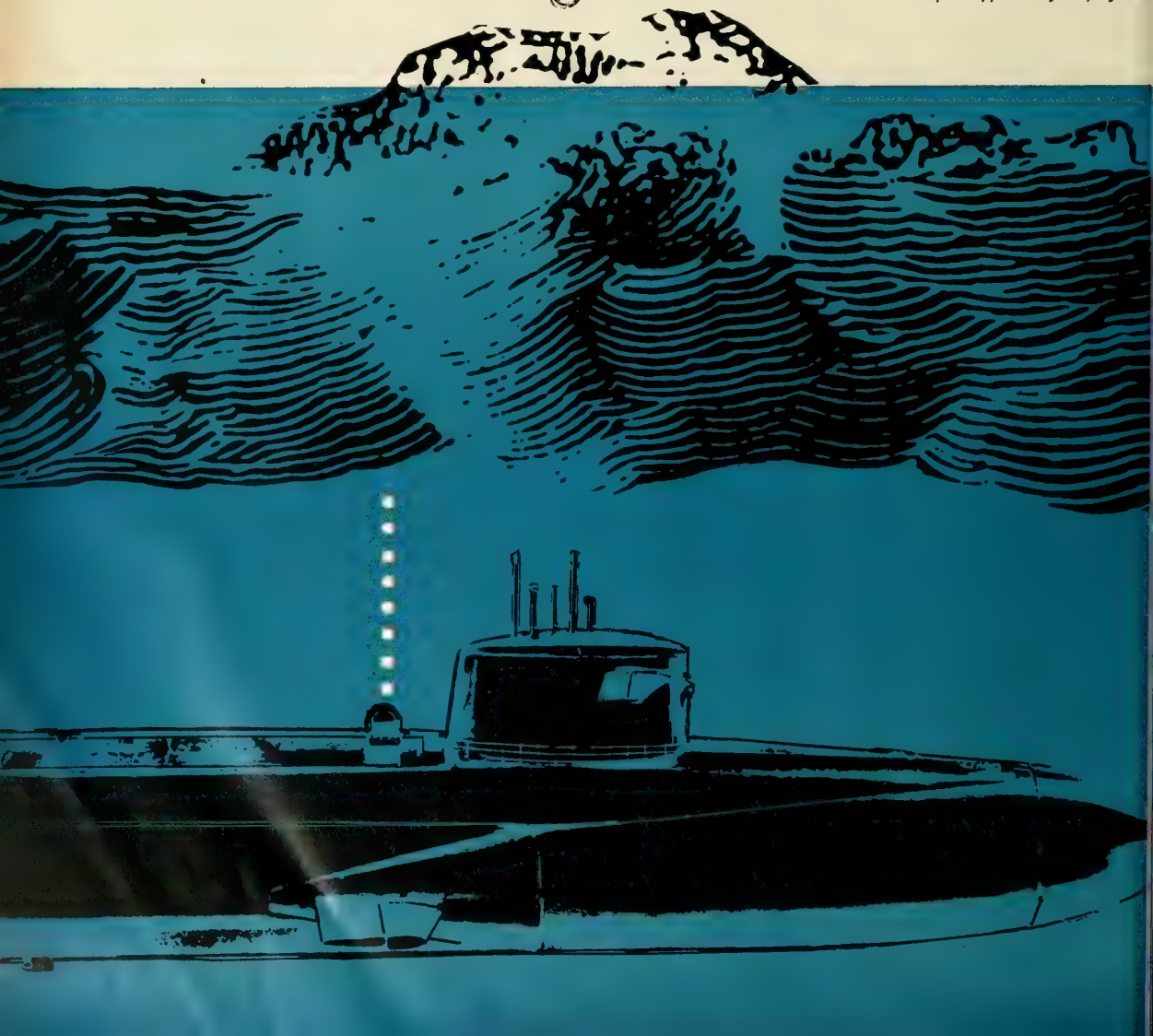
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Martell, Karaberis Share Management Responsibility in Separate Offices

Director, ASW Programs, and Manager, ASWS Project, operate along different command lines although both report to Secretary of Navy; service feels new team will improve relations with industry

VICE ADM. Charles B. Martell—director of the Navy's anti-submarine programs—has been termed "Mr. ASW" by Chief of Naval Operations Adm. David L. McDonald.

To the extent that the Secretary of the Navy and the CNO look to Martell for reports on the requirements and operational aspects of ASW, this is true.

However, there is another, though less-heralded, "Mr. ASW" in the Navy. He is Rear Adm. C. A. Karaberis, who heads the ASW Systems project in the Office of Naval Material. Karaberis is charged with ASW producer functions within the Naval Material Shore Establishment.

The only place where the lines of authority come together is at the Secretary of the Navy level. Both Martell and Karaberis report directly to Navy Secretary Paul H. Nitze.

The directive establishing the ASWS project provides for a direct line between Martell and Karaberis. "In matters relating to requirements, the selection of work to be performed and its appraisal for military worth and readiness," it states, "the Manager, ASWS Project, will look to the Director, ASW Programs in the Office of CNO (Op-95) for guidance and direction."

The directive also "authorizes and directs" direct communication between the two offices "to ensure the free crossflow of information and ideas essential to melding of requirements and capabilities. . . ."

Command lines run from Martell through the Chief of Naval Operations and from Karaberis to the Chief of Naval Material.

- **Op-95, coordinator**—The chief of the ASWS project enjoys the status of a designated project with "a priority within the Navy second only to the Fleet Ballistic Missile Project," and he has authority over the Bureaus commensurate with this responsibility.

Martell, in contrast, has authority only as a coordinating agent of the CNO. His role is to pull together all ASW planning, programming and appraising to ensure an integrated and effective ASW effort. While Martell says he "feels completely responsible for the success or failure of any ASW program," he admits that his effectiveness depends on the intent and desires of the Secretary of the Navy and the CNO."

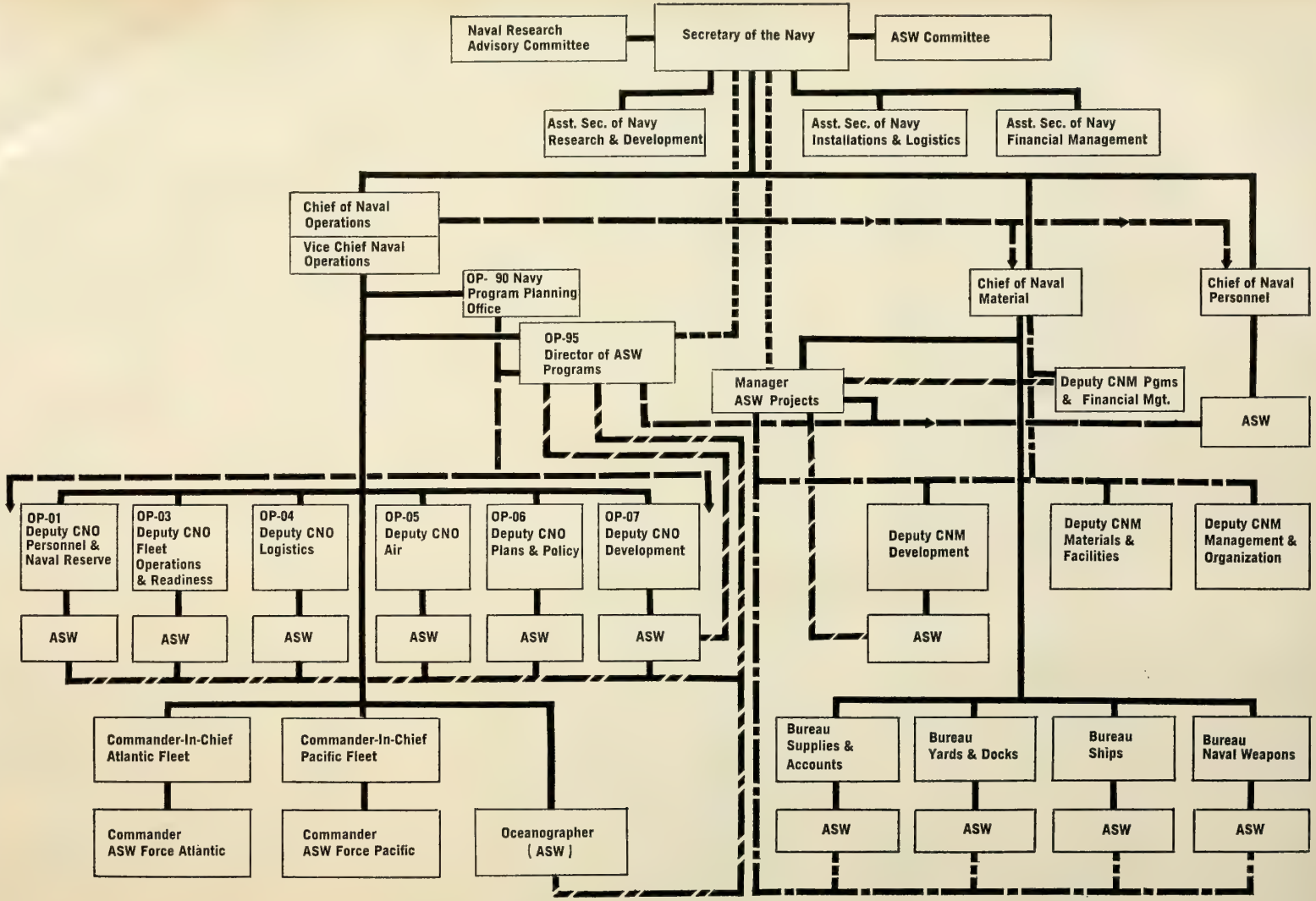
At the moment, this high-level interest is present. Martell, in discussing the reasons for failure of an earlier effort at pulling together the Navy ASW program (see below), said, "Op-001 never had any real authority; he was an advisor, and nothing is easier to circumvent than an advisor. I not only advise



LEFT: Vice Adm. Charles B. Martell, director of anti-submarine programs, reporting to CNO. "We intend to take a horizontal cut out of the vertical organization . . ."

RIGHT: Rear Adm. C. A. Karaberis, head of ASW Systems in Office of Naval Material, "We are trying to bring to bear a maximum number of people and equipment in a coordinated team effort."





ASW ORGANIZATION

but control. No one can pick up a pencil around here without my approval.

"Of course, the CNO can listen to others but, if he does, there is no point in having this office," he concluded.

Martell see his job as consisting of two tasks: "We have to more clearly define the crucial elements of the program, see that these are supported and see that they are on schedule. In the past, there was no order of priority and some programs were carried along on shoestring funding. The remarkable thing is that we got anything out of them. We intend to establish priorities and see that these programs are properly managed and supported."

The second task is "to see that some things are done that have been talked about for a long time." A corollary to this, the Admiral says, is that "We don't intend to waste resources on minor programs."

● **Past and present**—Martell attributes his position and authority to three influences: the great interest of the Secretary, the "real prodding" by Congress and the realization within the Navy itself that ASW needed more attention.

In a "Brief History of ASW Organization," the establishment of Op-95 is attributed to "a series of evolutionary adjustments." Prior to 1958, the Undersea Warfare Division, Op-31, handled ASW as well as submarines and mine warfare for the CNO. In January, 1958, Op-001 came into being as the ASW executive directly under the CNO, but the ASW program remained in Op-31. This was the advisory function which Martell decried.

In 1961, the ASW Division, Op-32, was established and at the same time Op-001 was dissolved. ASW and mine warfare functions were transfered from Op-31 to Op-32. Finally, on Feb. 17, 1964, Op-95 was established and the Navy was embarked on its latest and most determined effort to solve the ASW problem.

Martell's organization is small and will remain so. "Everybody keeps harping on organizations," he explains, "but, just as in industry when there is a job to be done, we intend to take a horizontal cut out of the vertical organization."

In practice, this means that ASW groups within the already existing Ops —Manpower and Naval Reserve, Fleet Operations and Readiness, Logistics, Air, Plans and Policy and Development —will remain where they are. They will report to the chiefs of these Ops, but also will be subject to the coordinating authority of Op-95.

The biggest problem facing him, Martell feels, is "to get a handle on the Navy ASW program in order to obtain data to analyze and to recommend a program . . . And, to make sure that this program is based on facts." One of the approaches being considered to help solve this problem is contracting for systems engineering assistance.

● **ASWS project definition**—On the Material side of the picture, Karaberis' charter specifically excludes platforms from his cognizance.

"The term ASW Systems," the directive says, "refers to those surveillance, detection, classification, localization, fire control, and weapons components and systems in ships, submarines, aircraft and fixed installations as distinguished from the ships, submarines, aircraft or sites of the fixed installations for which these ASW Systems are designed and procured."

Although platforms are excluded from the charter, there is a built-in requirement for responsiveness to ASWS requirements by the Bureau of Ships "to the extent that they affect ASW systems and their integration into the platforms." An additional interlock is provided by Martell, who serves as a member of the standing committee for Shipbuilding and Conversions, the Ship Characteristics Board, the Air Board and the CNO Advisory Board.

Implementation of the charter is now under way. One of the first steps taken was the full-time assignment of eight officers and 60 personnel from the Bureau of Ships Sonar Systems Project Management Office to Karaberis. This is in keeping with Adm. W. A. Schoech's directive to establish direct supervision "as rapidly as possible" in areas of critical importance—such as surveillance and control, systems analysis and engineering, and control of technical interfaces for surface ships, submarines and aircraft.

The general management structure of the ASWS project is along the lines of the Navy's Special Projects Office, which runs the *Polaris* program. Capt. Thomas A. Rutten, Deputy to Adm. Raborn for three years in the Special Projects Office, holds a comparable position under Karaberis.

● **Business, not as usual**—In carrying out his job, Karaberis stresses that he intends to change things. The Secretary of the Navy, he says, was concerned with the fact that a "bits-and-pieces" approach was being taken toward ASW —that is, individual components were being developed without a long-range, end-of-the-line view of how they fit into the total system. Secretary Nitze was also concerned with the fragmented technical direction within the Bureaus and with the lack of centralized management.

"My own review confirmed the Secretary's view," Karaberis says. "We have a lot of splendid ASW talent in the Bureaus, but the job is big and this talent is spread too thin." He is therefore in the process of pulling together the various pieces. As a parenthetical note, one Navy official estimated that there were 54 organizations within the Navy working directly in the area of ASW.

Karaberis sees his organization fulfilling three principal functions:

—Systems Analysis, which would include both the analysis of requirements from the CNO and systems synthesis or the molding together of existing equipment.

—Management to include plans, programs, financial management and long-range projections.

—Technical direction to ensure that needed equipment is developed on time, within cost and with specified performance.

Another area, probably as important as the first three, is the weeding out of unfruitful areas of development.

Karaberis believes the most immediate problem is to work on today's problems while at the same time developing a management structure for the long term. Now that the sonar group is under his control, the Admiral is working to bring together the widely scattered Surveillance and Control systems personnel. After this, personnel working in the areas of weapons and launchers for ASW will be centralized.

● **No Bureau status seen**—However, it is not the Navy's intention to create a Bureau of ASW. Only those elements that need emphasis will be "projectized" —and primarily this applies to sensors rather than platforms.

Both Martell and Karaberis strongly feel that there is no breakthrough in sight in the ASW field. Therefore, they are concentrating on producing evolutionary progress in all areas.

Karaberis sums it up this way, "a team effort is essential to progress. No single person or piece of equipment is going to provide the answer. Therefore, what we are trying to do is to bring to bear a maximum number of people and equipment in a coordinated team effort.

"A fine job has been done convincing industry we need help," Karaberis said, but M/R interviews with industry have shown there is some feeling that ways and means of helping the Navy have not been spelled out.

Seahawk, the advanced ASW ship, is a good example. The Navy argues that this is a very important, very active program, which is "under detailed study" or "being re-oriented." Consensus of industry officials, however, is that the "program is dead."

This lack of communication continues to be a problem, but one that the Navy recognizes. The Navy feels that, with Martell and Karaberis, it has a centralized management team that will be able to keep industry informed. ■



Dual test stand for static firing of the Saturn V 7.5 million pound thrust booster stages at the National Aeronautics and Space Administration's Mississippi Test Operations. Architects and Engineers: Sverdrup & Parcel and Associates, Inc., St. Louis, Missouri.

strong, safe, durable

Steel H-Piles to support test stand for Saturn V

Before the Saturn V moon rocket roars into space from Cape Kennedy, the S-IC first stage, whose engines will have a combined thrust of 7.5 million pounds, will be completely tested at the National Aeronautics and Space Administration's Mississippi Test Operations —a division of the Marshall Space Flight Center. The dual test stand foundation will rely on USS Steel H-Piles for dead and live load support in addition to withstanding operating loads from the large thrust generated by the rocket engines.

The giant rocket stages are too big for freight cars so they will start their journey to the moon on barges. The stages are assembled in the Michoud plant in New Orleans and shipped about 38 miles to the test facilities being built on about 142,000 acres in Mississippi and Louisiana.

To form adequate foundations for the first of the huge test structures, 1,640 USS Steel H-Piles (14 BP 73) were driven through several layers of unstable fat clays to friction bearing in dense sand below —71 ft. Rock for end bearing was out of reach. Some of the piles are driven vertically but most of them are battered on a slope to help resist both horizontal and vertical forces caused by tremendous engine thrust and to give necessary horizontal stiffness.

Piles under the test stand are designed to support total dead and live loads of approximately 160,000 tons and a maximum horizontal load of 8,000 tons. An additional problem was the vibratory load which will be imposed by the gimballing of the booster engines. This is generally not a consideration in foundation design but was important here since the vibrations could cause additional driving of the piles.

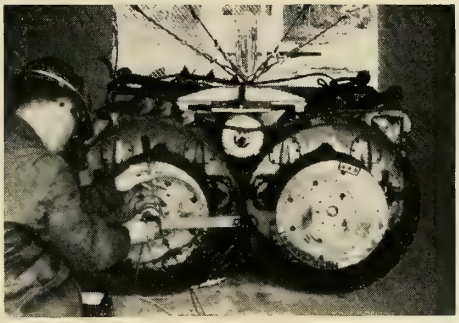
The Mobile District Office of the U. S. Army Corps of Engineers conducted an extensive series of pile tests on piles of various materials at the site in advance of final design. These preliminary pile tests were necessary to determine safe and economical design loads, driving characteristics, necessary penetrations and to observe performance under vibratory loads.

As a result of the tests, 14″-73# steel H-piles were selected as the basic pile for which bids were asked. Design loads specified are:

a. 100 tons compression and 40 tons tension for long term loadings.

b. 125 tons compression and 40 tons tension for long term loadings.

c. 140 tons compression and 40 tons tension for load combinations including wind.

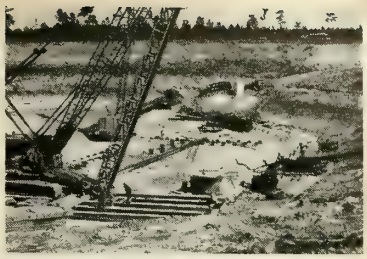


Vibration generator is used in combination with heavy static load to determine performance of test piles under combination of dead and vibratory loads. Steel H-Piles performed very well in these severe load tests up to about 250 tons combined loads. Tests were conducted by the Mobile District Office—Corps of Engineers with Vicksburg Waterways Experiment Station. Sverdrup & Parcel and Associates, Inc., St. Louis, were design engineers.

d. 200 tons compression and 100 tons tension for load combinations including the blast load resulting from a catastrophic explosion at any adjacent test stand.

Alternate "or equal" pile types were permitted; however, USS Steel H-Piles were selected by the contractor because—

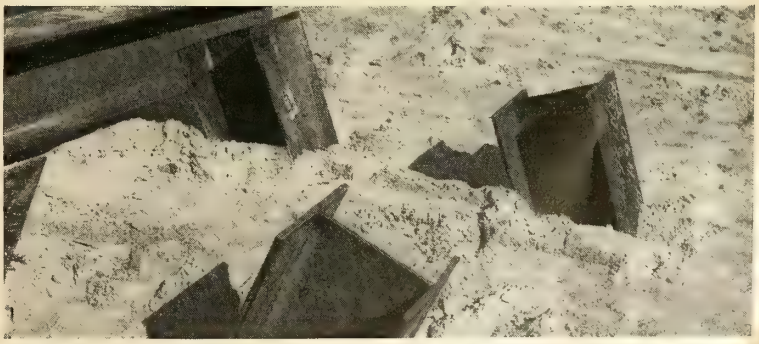
1. Minimum displacement of steel H-piles meant a minimum of trouble penetrating through the fat clays overlying the sand.
2. No pre-coring was necessary with H-piles.
3. H-piles are best for getting fast penetration into the dense sand.
4. They are easily spliced or cut off where necessary.
5. They can be readily driven on a batter.
6. They are the best piles to withstand horizontal and extraction loads.



General view of test site with first USS Steel H-Piles already driven. The pile driving contractors are W. R. Fairchild Construction Company and J. W. Snowden Construction Company, Joint Venture, of Hattiesburg, Mississippi.

USS Steel H-Piles offer many advantages for jobs like this and other construction. They drive better than piles of other materials, can be easily spliced or cut, can take hard driving, are easy to handle and store, and are a finished product shipped right from the mill ready for use and are readily available in various sizes and foot weights. When you specify products from United States Steel, you can count on helpful technical assistance, quality, service, and prompt delivery.

Write for a copy of our new 91-page book, "USS Steel H-Piles," for more information on accepted practice on design and utilization of steel H-piles. United States Steel, Room 7421, 525 William Penn Place, Pittsburgh, Pa. 15230.



USS Steel H-Piles in lengths up to 93 ft. were driven at opposing batters for maximum stability.

USS United States Steel

TRADEMARK

ASW Budget Running at $386.5 Million But Past Approach Hampers Work

FUNDING for anti-submarine warfare programs—already some 27% of the Navy's Research, Development, Test and Evaluation (RDT&E) budget—is not likely to show an explosive growth over the next several years.

In spite of its status as a designated project second in importance only to the Fleet Ballistic Missile program, ASW suffers less from lack of funds than from an earlier lack of direction.

Adm. Martell told MISSILES AND ROCKETS that in the past "there was no order of priority" and some programs got only "shoestring funding." He said "the remarkable thing is that we got anything" out of the past programs.

Adm. Karaberis noted that Secretary of the Navy Paul H. Nitze is "concerned over the 'bits and pieces' approach to ASW in the past."

Therefore, much of the effort of the two central figures in the Navy's revitalized ASW effort has been to review the Fiscal 1965 ASW package—drawn up and presented to Congress before either assumed his present position—and to recommend changes. This review has been completed and changes have indeed been made in the program—substantial enough so that the Navy has had to ask Congressional authority to reprogram funds.

The nature of these changes has not been disclosed. However, the areas of chief concern to the Navy are known.

● **What do we have?**—A major effort will be mounted to determine the capabilities of equipment already in the fleet—sonars, fire-control equipment and platforms:—airborne, surface and sub-surface. Martell feels that a better understanding of these systems will yield some very real benefits. "It is extremely difficult," he points out, "to reconstruct an ASW action. But it can be done and it can be very worthwhile."

There will be a concurrent drive, of importance to industry, to reduce the interfaces between ASW subsystems. The "bits and pieces" approach of the past has yielded equipment which, although it can be made to work with other subsystems, does not add up to a total system "from transducer to weapon."

One Navy official puts it this way: "A sonar man is working on a very advanced system and, in the past, he would assume that the fire-control man was developing a system to handle the outputs from this transducer and both

CHIEF, NAVY PROCUREMENT ACTIVITIES

BUREAU OF NAVAL WEAPONS
DEPARTMENT OF THE NAVY
WASHINGTON, D.C.
TEL: OXford 6-7470

Interests: Guided missiles, airframes and aircraft subsystems, armament and fire control equipment, electronic systems, navigation equipment, torpedoes and research and development for these items.

BUREAU OF SHIPS
DEPARTMENT OF THE NAVY
WASHINGTON, D.C.
TEL: OXford 6-3362

Interests: Ships and ship repair, minesweeping gear, interior communications systems and electronic equipment including radar, radio, radiac, etc., navigation systems, sonar and small boats, including research and development needs for these systems.

BUREAU OF YARDS AND DOCKS
DEPARTMENT OF THE NAVY
WASHINGTON, D.C.
TEL: OXford 6-3281

Interests: Floating dry docks, cranes, power plants and permanent facilities (including real estate acquisition and disposal). Responsible for the Navy's construction projects as well as maintenance and repair, including public utilities.

OFFICE OF NAVAL RESEARCH
DEPARTMENT OF THE NAVY
WASHINGTON, D.C.
OXford 6-6650

Interests: Basic and applied research, including fundamental studies in such fields as electronics, chemistry and physics. Also coordinates research programs of the technical bureaus.

NAVY PURCHASING OFFICE
TEMPORARY D BUILDING
4TH ST. & INDEPENDENCE AVE., S.W.
WASHINGTON, D.C.
TEL: OXford 6-6900

Interests: Missile containers, missile components, electric and electronic components, antennas, radar components, mine components, research and development, test and analytical services and material as requested by naval activities in the Washington, D.C., area.

NAVY PURCHASING OFFICE
929 SOUTH BROADWAY
LOS ANGELES 15, CALIF.
TEL: Richmond 9-4711

Interests: General procurement for naval activities in the Los Angeles area, e.g., guided missile components, communications equipment, telemetry equipment and some research and development required by Pacific Missile Range activities.

assumed the weapons man was developing a kill mechanism which would fit with the other two. The first time the three pieces of equipment got together was on the dock and that is no place to resolve interface problems."

"We hope to reduce the interfaces to one—between a completely integrated ASW system and the platform which will carry it," he added.

A major step in this direction was taken with the initiation of the A-New program—an effort to provide an integrated ASW system for aircraft. The Fast-Reaction Integrated Submarine Control (FRISCO) is expected to provide the basis for the design of an integrated control system for submarines. It is expected that a surface-ship program similar to the other two will be undertaken.

● **Making it better**—In addition to integration of existing subsystems, a major source of business will lie in increasing the reliability, maintainability and at-sea operational readiness of already installed equipment. Although ASW equipment is sophisticated, Navy officials feel that much more can be done to "give our ASW forces equipment that will work more reliably at-sea"—and that can be maintained by Navy specialists or equipment operators.

An effort to upgrade the reliability of ASW equipment is pointed up dramatically in the Secretary of the Navy's directive creating the Anti-Submarine Warfare Systems Project. One of the purposes of the directive is "to obtain increased emphasis on ASW projects in development, production and fleet support in order to have all ASW systems planned and presently in ships, submarines, aircraft and fixed installations fully capable of operation at designed potential at the earliest practicable date."

An analogous program is Adm. E. T. Reich's "get well" campaign for the antiair weapons *Tartar, Talos, Terrier*. This effort, which is progressing well, represents an investment of over $275 million to correct the operational deficiencies of the three missiles. This is over and above the $1.4 billion investment that the Navy paid to develop and deploy the systems.

A comparable effort may be required to enhance the capability of present ASW systems.

● **New business**—Initial emphasis in the development of new ASW equipment will be in the areas of sensors, signal processing, classification and fire control—and essentially in that order of importance. As former Assistant Secretary of the Navy for R&D, James H. Wakelin, told Congress, "our ability to kill is much better than our ability to detect and classify."

Reflecting the almost universal Navy belief that no scientific break-throughs are available in ASW, the stress is on developing "from scientific principles the best engineering capability in the (sonar) area that we can."

There are five major programs in asdic systems in the '65 budget: a submarine sonar for the 1970 time period; a new passive-type sonar; a deep-submergence sonar for deep-diving Dolphin experimental submarines; improvements in the reliability and maintainability of the BQQ-1 sonar now in use; and incorporation of performance improvements in the BQQ-1 incorporating state-of-the-art advances since the initial design.

Variable-depth transducers are receiving major attention. Three sonars are involved: the VDS SQA-10 now in the fleet will be improved, and there will be operational evaluation of a new system and a system suitable for Seahawk-type destroyer escorts. New potential has been discovered recently in VDS and the Navy wants to exploit it.

Surveillance systems, the most classified area in ASW, apparently also are involved in stepped-up ASW activity. Caesar and Colossus, passive detection schemes, have been tested on the East and West Coasts. A network of passive listening devices is likely to be installed along the continental shelf on both coasts. Radio-isotope power supplies are under consideration for an operational system.

Active detection schemes, based on Artemis, are extremely promising. The difficulty appears to be a controversy over the advisability of an active surveillance system whose location can be pinpointed by the enemy. One Navy official asserts that it is possible "to ensonify the entire East coast" out to

U.S. NAVAL SUBMARINE BASE
NEW LONDON
GROTON, CONN.
TEL: 449-3011

Interests: Submarine equipment and supplies, alarm and signal systems, plastic and metal sonar domes, compressed gas cylinders and sound-insulation engine mounts.

NAVAL AIR DEVELOPMENT CENTER
JOHNSVILLE, PA.
TEL: OSborne 5-7000

Interests: Computers, navigational and flight instruments, engine instruments, experimental instrumentation telemetry, target systems, solid-state electronics and electronic countermeasures.

U.S. NAVAL WEAPONS LABORATORY
DAHLGREN, VA.
TEL: NOrth 3-2511

Interests: Experimental research and development services, missile warheads and explosive components, engine accessories, woodworking machinery and equipment, metal working machinery.

U.S. NAVAL ORDNANCE LABORATORY
SILVER SPRING, MD.
TEL: 434-7100

Interests: Miscellaneous electronic components, marine hardware instruments, laboratory equipment (microscopes, spectrometers, spectrophotometers and tachometers).

U.S. NAVAL ORDNANCE TEST STATION
CHINA LAKE, CALIF.
TEL: Ridgecrest 5-0111

Interests: Research and development and testing equipment in connection with missiles, rockets, etc.

U.S. NAVY MINE DEFENSE LABORATORY
PANAMA CITY, FLA.
TEL: ADams 4-2281

Interests: Underwater sound equipment, sound recording and reproducing equipment, electrical control equipment, radio and television equipment, instruments and laboratory equipment.

U.S. NAVAL RESEARCH LABORATORY
WASHINGTON, D.C.
TEL: JOhnson 3-6600

Interests: Chemicals, communications equipment, nuclear equipment, electronic components, insulating material, radio hardware, metals, optical equipment, material and equipment services.

U.S. NAVAL OCEANOGRAPHIC OFFICE
WASHINGTON, D.C.
TEL: JOhnson 8-9060

Interests: Oceanographic shipboard systems, oceanographic synoptic systems, offset presses, zinc plates, lithographic inks, skid turners, electronic test equipment.

U.S. NAVAL TRAINING DEVICE CENTER
PORT WASHINGTON, N.Y.
TEL: POrt Washington 7-3800

Interests: Training aids and devices for Navy personnel. Includes procurement of hardware and research and development effort for training devices to simulate shiphandling, communications, gunnery, fire-control, operational flight training, weapons systems trainers, human engineering. Engineering services for various devices.

distances of 500 mi. and detect anything that moves in the ocean.

Data-processing requirements stem in part from the Navy's need to quickly and accurately determine range and azimuth to a target, but more importantly from the need to classify a contact—whether or not it is a target. If signal enhancement techniques and high-capacity data-processing systems can be developed for ASW, the Navy hopes to increase the speeds with which ships can search a particular area. This becomes extremely important in Seahawk-type ships whose *raison d'être* is their high search rate.

Data processing would be extremely important if the Navy decided to develop a complete ocean surveillance system. However, one Navy official told M/R that such a system had been postulated and costed and that, although it was within the financial capaciy of the Navy to support, the system would be technically obsolete before it was operational. It is possible that advances in the state of the art over the past several years may have changed this.

Classification equipment is also a market for future exploitation. Improved magnetic anomaly equipment, infrared, laser, radioactivity and shipboard signal analyzing systems. Programs to counteract the magnetic field created by an aircraft, ship or submarine electronic systems are also coming to the fore. One program in this area is NUTMEG, a joint U.S.-Canadian venture, which seeks to counteract the fluctuating magnetic field created by airborne sensor systems.

Development of hydrofoil technology for ASW will have to wait the completion of presently approved programs —such as the Ageh-1. This is a 320-ton hydrofoil research ship being built by the Puget Sound Bridge & Drydock Co. Scheduled for completion in November, 1965, it is expected to yield information on the optimum design of large oceangoing hydrofoils and to evaluate tactical capability—particularly for ASW.

Seahawk, the Navy stresses, is not a "dead program"—even though it has not been able to convince industry of this fact. Development of an advanced radar and the sonar mentioned earlier will continue, as will development of a data-processing system capable of the high search rates required.

A ship that could fill industry's definition of Seahawk is not likely to enter development much before the FY '69 budget. Inputs from the Ageh-1 as well as the preliminary design state of the subsystems for the integrated weapon will preclude its development for at least three years.

Although some weapons development work will proceed, the emphasis is decidedly away from development efforts in this area. Navy officials feel—as evidenced by Secretary Wakelin's comment in connection with detection equipment—that kill mechanisms are the least of their worries. Developments in this area, as pointed out in the weapons story (see p. 65), will tend to place emphasis on conventional warheads for existing weapons.

A very distinct marketing possibility, however, is the integrated ASW aircraft, which will be a follow-on to the A-new effort. This aircraft, as pointed out in the story on ASW sensors (see p. 54), is about two years away from release for industry competition. It would replace the S-2 tracker series of aircraft presently deployed on ASW carriers.

Oceanography in the past has been a disappointing field for industry in the past. Despite the attention given this field three years ago, particularly in the TENOC plan, the large contracts that industry expected did not materialize. This situation is not likely to change, since oceanographic instrumentation is the major area of Navy interest.

A major program—discussed but not approved as yet—would involve a large number of relatively sophisticated ocean buoys, such as Nomad, anchored in the oceans of the world to provide synoptic data on sea conditions. This data would be relayed to a satellite upon interrogation and re-transmitted to a shore-based station. Many Navy officials feel that such a system is required.

● **ASW funding**—Since Fiscal Year 1961, the ASW budget has increased from $248.3 million to $386.5 million —more than 50%. As a percentage of the Navy research and development program, the budget has increased from 18 to 27%.

Most of this increase has taken place in the aircraft category, reflecting expenditures on the SH-3A ASW helicopter and the P-3A shore-based aircraft and the systems carried by these planes. The only other category which has increased substantially is Ships and Related Equipment. Most of this increase is related to work on hydrofoils and the ship-silencing program.

Ordnance increases are accounted for by the Mark 46 development and the increased costs associated with the development of *Subroc* as a result of the Thresher loss.

Although the chart shows an increase of almost 50% for the Navy's oceanographic program, this figure should be regarded with some skepticism.

As pointed out in the oceanography section, the Navy asked for $106.9 million in Fiscal 1964. The Congress did not cut this request, but did make an across-the-board cut of 3% in the RDT&E category. The Navy applied this cut to oceanography, reducing the 1964 program to $88.1 million—cutting far more than 3%. Two-thirds of the 1965 budget will be applied to RDT&E and operation and maintenance.

● **Procurement note**—There are no purely ASW procurement centers in the Navy. Rather, the major bureaus and ordnance installations handle such developments as a part of their normal operation. A list of the principal centers involved in work of this kind is included in the accompanying chart. ■

Navy Oceanographic Program

	Fiscal Year 1963	1964	1965 *
Research, Development Test & Evaluation	30.1	35.7	44.6
Operation and Maintenance, Navy	31.1	32.2	36.2
Office of Personnel, Navy	2.4	5.1	3.9
Shipbuilding and Conversion, Navy	18.4	8.2	28.6
Military Personnel, Navy	6.8	6.9	7.0
TOTAL	88.8	88.1	120.3

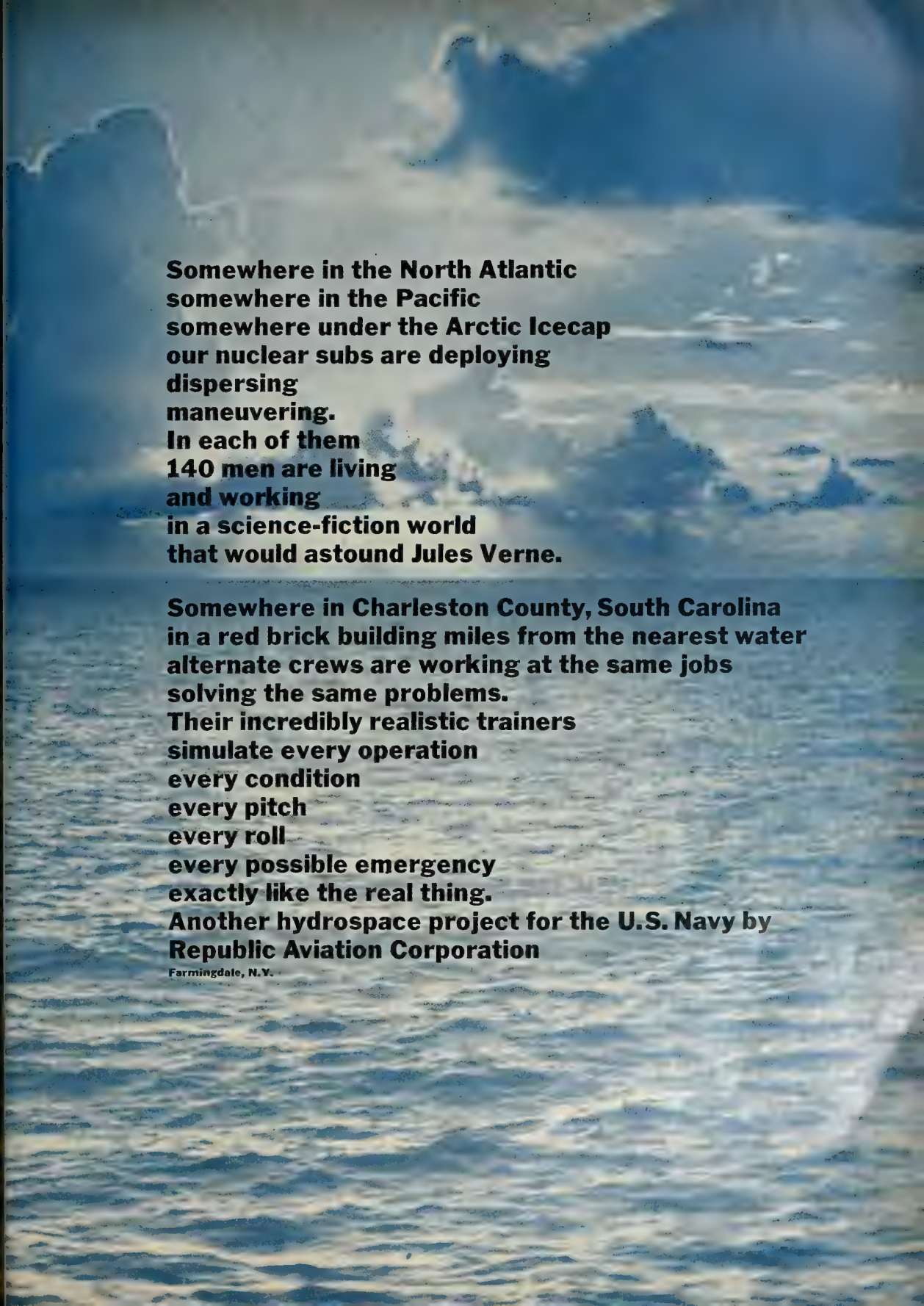
* estimated

ASW Program, New Obligational Authority, Research, Development, Test and Evaluation

Budget Category	Fiscal Year 1961	1962	1963	1964	1965 *
Military Sciences	49.6	39.6	50.6	52.1	58.8
Aircraft & Related Equipment	16.5	18.0	30.6	49.1	65.4
Missiles & Related Equipment	31.2	34.5	38.0	16.0	6.4
Military Astronautics	—	.1	.3	.3	.7
Ships, Small Craft & Related Equipment	79.8	81.4	114.2	141.2	146.5
Ordnance, Combat Vehicles & Related Equipment	51.5	42.1	52.4	58.9	76.5
Other Equipment	3.7	6.1	5.8	7.6	9.8
Programwide Management & Support	16.0	11.1	25.0	24.9	22.4
TOTAL	248.3	232.9	316.9	350.1	386.5

* estimated

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every roll
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Another hydrospace project for the U.S. Navy by
Republic Aviation Corporation
Farmingdale, N.Y.



two oceans, one discipline



60 fathoms down or 60,000 miles out — in the new ocean of space — men and machines are far from port. There are no lines of supply to ships on station or to satellites in orbit. Reliability must be built in; self-reliance must be total.

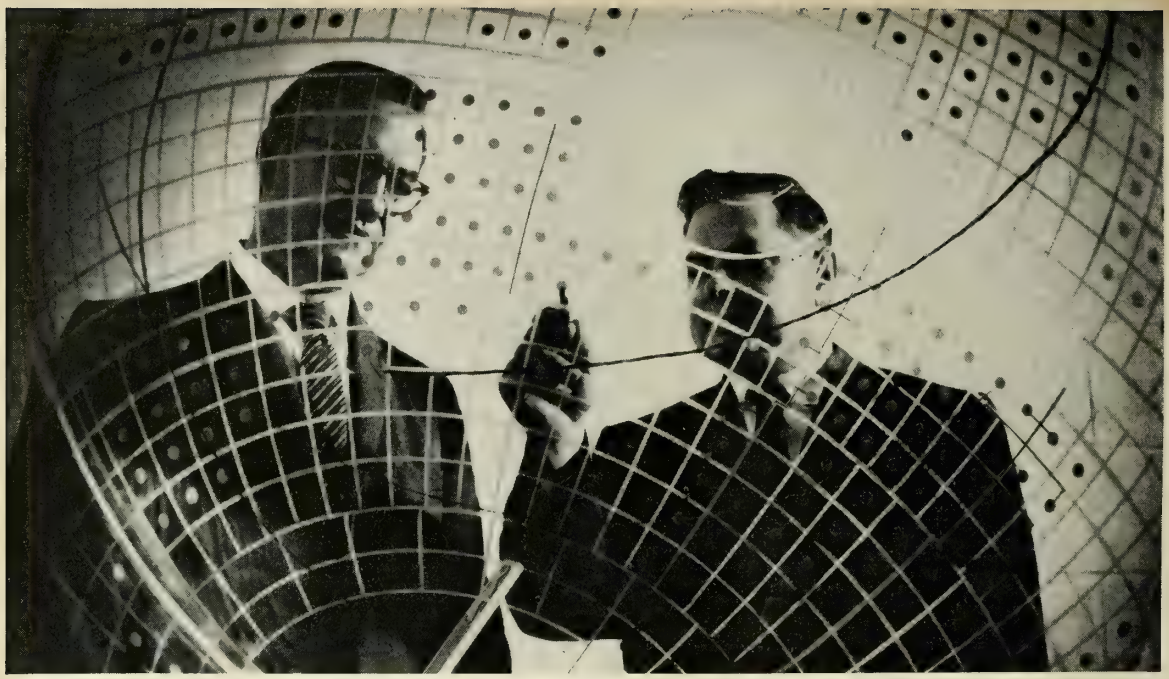
Although an old story for subs and ships, it is new for spacecraft. Until now, satellites had limited working lives; their productive time was measured in hours and days. But TRW Space Technology Laboratories changed this picture with its Nuclear Detection Satellites. These space sentries, orbiting 60,000 miles out to detect nuclear explosions, have performed far beyond expectations — setting a record for spacecraft reliability.

The discipline of space, demanding reliability and longevity, is a TRW discipline. TRW has built more kinds of spacecraft than any other manufacturer. It has had a major responsibility in 90% of all U.S. space launches. These vehicles will never see drydock.

TRW SPACE TECHNOLOGY LABORATORIES

THOMPSON RAMO WOOLDRIDGE INC.

ONE SPACE PARK · REDONDO BEACH, CALIFORNIA



AT RAYTHEON'S Anti-Submarine Warfare Center, Portsmouth, N.H., transparent sphere helps locate transducers on nuclear subs.

ASW special report

Detection, Classification Are Key Jobs

Lower frequencies seen for sonar; attention to target classification problems paying off, but broader capability needed

DEVELOPMENT of detection equipment for the U.S. anti-submarine warfare (ASW) effort falls into three broad categories: underwater active and passive sonar systems for surface vessels and submarines, airborne search and sensing systems for fixed-wing shore- and carried-based aircraft and helicopters, and an expanding program of fixed deep-water listening arrays.

Associated with these major areas are expanding programs in study of new sonar systems and ASW roles for deep submersible vehicles, satellite data-collection potential, and the entire area of undersea communications to link submarine forces with surface vessels and aircraft.

Stretching across all areas is the second-step problem of classification (and localization), which embodies most of the new signal processing and data-handling techniques being applied to ASW.

● **New sonars**—The next round of improvements in the Navy's sonar detection capabilities will come from two new systems now undergoing operational evaluation—the SQS-26 sonar for destroyer-type vessels and the BQQ-2 for Thresher-class attack submarines.

Both of these systems, according to the Navy, "have demonstrated their capability of detecting submerged submarines at several times greater ranges than any previous equipments." Both sonars are also the first capable of making detections using convergence-zone techniques and deep-water bottom-bounce methods, which are the long-range sound-propagation modes effective against nuclear submarines.

The SQS-26 is a hull-mounted circular-transducer-array system, employing several hundred barium titanate ceramic antenna elements, or staves, in the array. The SQS-26 is also believed to include a degree of solid-state circuitry, which is now beginning to heavily penetrate the sonar field, in the individual transducer amplifier sections.

The SQS-26 has been produced in two initial buys by both General Electric's Light Military Electronics Dept. (LMED) and the Edo Corp. The two firms are now reportedly competing for the third and largest buy of the system to date.

The BQQ-2 is actually the designation for an integrated system consisting of several elements built around the BQQ-1. Raytheon Co. holds the prime contract. The system includes a Raytheon BQS-6 active and passive spherical array sonar, an Edo BQR-7 passive-only conformal hydrophone array, and a BQQ-3 classification sonar which is actually a black box rather than a separate sonar array.

The latter is considered a predecessor for the future widespread introduction into the fleet of sonar frequency analyzer-comparator systems that eventually will replace the sonarman's rather hard-to-define data-storage base. The BQQ-2 also includes a Raytheon underwater communications system.

The BQQ-2, designed to operate



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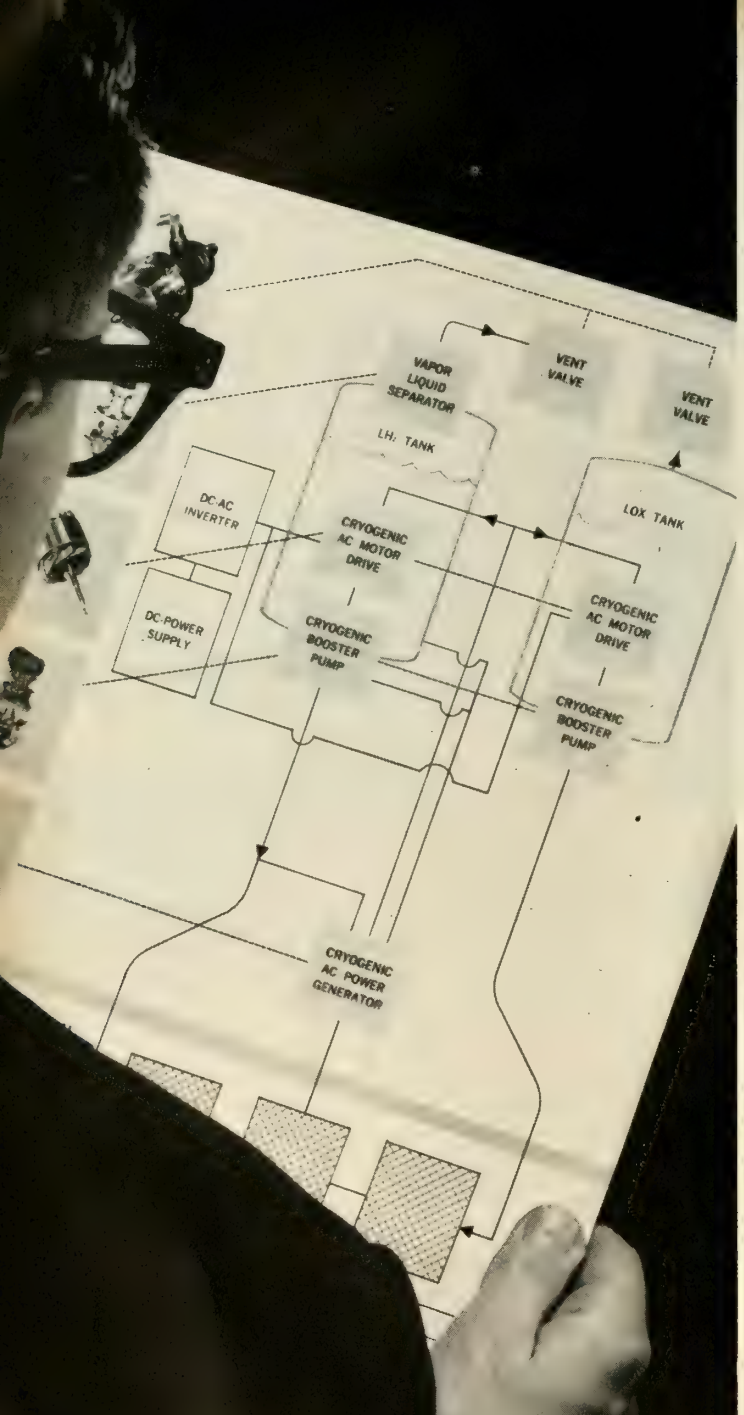
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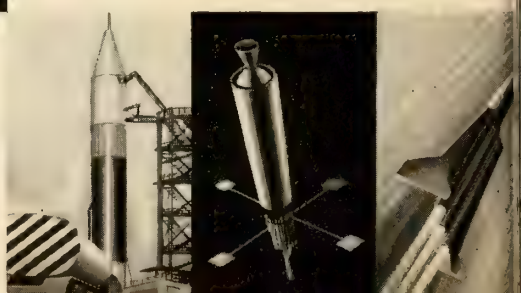
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with the *Subroc* missile, has reportedly ranged to the current maximum range of the missile, estimated to be on the order of 30 miles. The ability of the crew to classify at these ranges, however, is subject to the variations already noted.

• **De-bugging needed**—The BQQ-1 was described in Congressional budget testimony by the Navy as "not wrung out." The Navy said that although the system is already operating in the fleet "and doing some very fine things," it had not yet arrived at what it hoped to be the ultimate model of this sonar. Firm plans and specifications for the BQQ-1 will be available by January, 1966. Industry sources say more than 200 field changes have been made in the overall BQQ-2 system thus far.

Weapons experts point out that *Subroc* is still a highly effective weapons system even if not fired at its maximum range, and there are other weapons that fill the gap between the minimum range at which *Subroc* can be fired and the maximum range of alternate weapons. In any event, lack of new progress in detection and classification is likely to inhibit new long-range weapons systems development.

Both of these sonar systems also require smaller measurement systems for support, such as thermal layer sensing devices and depth and height (for operating under the Arctic ice) finders.

• **Variable depth sonar**—The SQS-26 does not include a lowered and towed variable depth sonar (VDS), but there are VDS systems under development that could operate with it. The forerunner of the SQS-26 system is the SQS-29 sonar, made by Sangamo Electric Co., which is the standard sonar currently in fleet use for destroyer (DD), escort, and cruiser vessels. There are still some earlier Sangamo SQS-29 sonars in the fleet on some DD's. The SQS-29 series did operate with a VDS, the SQA-10.

The Navy has supported development and is now evaluating a new VDS system, the SQS-35, which if it were produced in quantity would probably be in fleet use in a few years. The 35, also made by Edo, is believed to weigh about 10 tons—a major weight reduction from earlier systems. It is a self-contained system in that it carries its own transmitter and need not use the transmitter mounted in the ship's hull. Size of the 35 has reportedly been shrunk through introduction of integrated electronics.

While VDS has been around at least experimentally since the 1940's, only in the past four years has it gone into the fleet operationally. By first making measurements to determine the depth of isothermal layers, the VDS can then be lowered below these levels and towed to penetrate areas difficult for straight hull-mounted sonars to penetrate.

Development of a lighter weight system (present ones are believed to weigh about 20 tons) would remove the constraints on ships imposed by the heavy stern-mounted hoisting equipment. This would allow smaller vessels that cannot now carry VDS to do so, and might also allow other surface ships, which do not now have a hull-mounted sonar, to add an undersea detection capability.

While nuclear attack submarines are currently viewed as the best single weapon against another nuclear sub, development of improved VDS would add greatly to surface ship capability when added to the speed the surface ship can make with relatively little effect on its ASW proficiency in comparison to a sub moving at high speed.

There is also the problem of a submarine detected below a layer being lost by another sub. The target could go above the layer or go totally undetected because of the layer. This is why ASW is truly a task force operation for many situations.

Another new surface sonar system is the SQS-36, also being evaluated by the Navy. This system, also developed by Edo (a small firm with a major chunk of ASW funding) with Navy support, is for smaller coastal and patrol-type craft.

Whatever the fate of the Seahawk program (M/R, Aug. 24, p. 16), or a follow-on destroyer-vessel, the next class of ASW ships will have on it a new type and differently shaped (conformal or linear) sonar array, though still not classed as a breakthrough by industry sources. Such a development effort would likely involve several contractors in a program-definition phase.

• **Passive systems**—In surface and sub-mounted sonar, two new passive systems are also coming into fleet use. One is an outgrowth of the PUFFS (Passive Underwater Fire Control Feasibility Study) program. This system is already installed in some submarines and is said to be yielding greatly improved capabilities.

The other is the PADLOC (Passive Active Detection and Location), or SQR-13 sonar, designed for surface ship use. Both of these systems basically do the same thing—allow for a range solution using passive sonars, a long-sought-after capability under serious development for the past four years. The systems are believed to use single-ship trilateration techniques. Both systems are built by Sperry-Rand Corp. The Navy requested $2.1 million in FY '65 for a single development model of the SQR-13.

To overcome the disadvantage of a short baseline on a single ship, two ships acting in concert can be used. These ships can use a longer baseline between each other and thereby considerably extend the maximum range of both PUFFS and PADLOC.

One of the reasons passive ranging is so important to submarine ASW capabilities in particular is that it may allow the skipper of a sub to back off in some situations from the use of active ranging. While active systems are becoming highly refined, a sharp sub crew will know when it is being ranged upon and consequently insiders say submariners are often reluctant to use active systems.

Despite this, the Navy can't cut back on development of active systems because as the enemy's sub fleet goes progressively nuclear and improves its ability to operate quietly, the subs become increasingly more difficult to detect by passive techniques.

Edo has also developed the SQS-33 sonar, which is designed for hydrofoil use, an area that now has about as many problems (high speed towing is just one) as it has potential. The system is being evaluated on the Boeing PCH-1, the Navy's first hydrofoil subchaser, and is also said to be slated for test aboard the Navy's 300-ton Ageh foil, due to be completed in February, 1966, by the Puget Sound Bridge and Drydock Co.

Polaris boats have spurred development of what is described as a new and sophisticated conformal sonar array said to include advanced solid-state receiver circuitry. Two divisions of the General Instrument Corp. were recently awarded "*Polaris* Flags" for the development, which cost about $9 million.

Although classified, the system has been described as non-tactical and may not even go aboard *Polaris,* even though it is believed that the relatively short-range LF system may form the basis for a new terrain-following sonar. Four systems have been built and one is now under test aboard the USS Compass Island.

• **Sonar trends**—There are several trends apparent in sonar design. For one, the march to lower frequency operation for better acoustical propagation will continue, probably moving through the VLF range into the ELF. While own-ships' noise inhibited World War II subs from going too low in frequency, nuclear subs can operate considerably more quietly. Low-frequency operation is also said to be less inhibited by attenuations resulting from dome-type transducer housings located beneath or around the hull.

As subs go deeper, the sonar patterns generated become more stable. The bending of rays downward caused by decreasing temperatures, explains a Sperry scientist, combine with the upward bending movements caused by

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higher pressures to form the so-called sound channels, in which LF noise can travel literally for hundred of miles.

At lesser depths, these thermal gradients tend to act on sonar beams to reflect and refract them in such a way as to create "shadow zones," zones in which only powerful sonars will have limited penetration. These make excellent hiding places for subs.

Combined with this will be substantial efforts to get more and more power into the water. While WW II subs got a maximum of 800 watts output power, state-of-the-art sonar transmitter systems are now said to be capable of generating several hundred thousands of watts.

Part of the power problem is linked to increasing the sub's operating depth. If the sub can go deeper as materials improvements come about, increased pressures will allow greater amounts of power to be pumped into the water without causing the cavitations that come with too much power, and reduced detection capabilities, at lesser depths.

To multiply transmitted power beyond current levels, new transmitter arrays are being developed that will replace the single large systems that have characterized fleet sonars in the past. The Navy is pursuing this type of multi-element transmitter approach, which would introduce more transmitter control and also probably ease the introduction of more solid-state componentry into the transmitter area in the future. These transmitter elements would probably each act with a group of antenna elements that make up the transducer array.

● **Transducer potential**—In the transducer array area, the Navy is expected to move more and more into use of electronically scanned, fixed, multi-element systems. These will use narrower, high-power pre-formed beams, possibly with individual solid-state receivers on each channel and arranged in shapes other than the cylindrical pattern used most thus far. New and larger-area spherical, linear, and conformal arrays are expected. Increasing the size of the transducer surface is another way to get more power into the water.

Use of electrostrictive ceramics, such as barium titanate, for transducers is also expected to increase.

Numbers of transducer array elements have already increased from the few dozen used in early arrays to over a thousand, for example, in the BQQ-2 active sonar and probably several hundred in the SQS-26. Attempts will also be made to improve the efficient use of the elements to form the directional beams for both passive and active systems. One industry engineer says that now about three-eighths of an array is used to form a useful beam and receiver pattern.

Use of more directional transmission to get a much larger portion of the signal back is now highly important, especially for bottom-bounce. While early systems were made up of roughly 48 beams, each with a beamwidth of about 7½ degrees, newer systems, using microelectronics, with several hundred beams and beamwidths of a fraction of a degree, are now being studied by industry.

One contractor told MISSILES AND ROCKETS that systems with 1,000 beams could reasonably be expected 5-10 years in the future. Narrowing the beam width increases the information content and resolving power of the beam and cuts the noise but also may create associated display problems for the crews because of the large amount of data that would be generated.

● **Displays needed**—There is a good market in the ASW area for advanced displays able to function with these systems. One industry scientist says that seven bits per sec. is about all the human can handle, while advanced systems may be turning out data measured in hundreds of thousands of bits. Also associated with more narrow beams are larger antennas that relate to the study of new transducer shapes and the tradeoffs with marine architecture that can be engineered in the interests of improved sonar.

While new transducer arrays are definitely here, they are not without their problems, according to experts in the field. Spacing between elements must be carefully controlled to avoid beam interractions. There are also studies underway to determine why unequal loading of elements in an array occurs, its relationship to its position in the array, and its effect on the beam. Transducer waveguide breakdown at very high pressures is also being studied.

The Navy will also continue to seek improvements in the overall efficiency with which transducers convert electrical energy to acoustical, and vice versa. WW II transducers were about 15-30% efficient. Today's devices have reached about 70% in some cases. Some weigh up to 90,000 lbs.

Use of solid-state circuitry in new fleet sonars like the BQQ-2 in some cases will reduce equipment space and weight requirements by almost 90%.

Emphasis will also be placed on depression and elevation control of sonar beams, particularly for surface vessels where stability is believed to be somewhat more of a problem than it is with submarine sonar.

● **Beyond pulsed systems**—While ASW sonar has been almost exclusively designed around pulse transmission systems to date, Navy sources say there

may be other than pulsed systems used in the future. Continuous transmission FM-type systems and so-called side-looking sonars, for example, have already been developed, but thus far have been associated mostly with shorter-range higher-frequency high-resolution sonars used in deep-diving research vehicles for detailed bottom measurements. The techniques may be applicable to the more traditional ASW roles in the future.

There are also believed to be other classified techniques under study.

Within the pulse field, the Navy is also known to be exploring other rather unconventional pulse transmission with "special character" signals and even multiple, but separated, signals operating in the same LF range. Use of two signals could improve signal correlation through comparison and could also act as insurance against interference at one frequency. The two-frequency concept has already been applied to side-looking sonar.

Side looking and CTFM sonars are believed to have bearing resolutions on the order of a fraction of a degree when operating in a high-resolution mode, and range resolution measured in inches. This capability may extend to ranges of a few hundred yards. These sonars have a search mode that goes much farther but at reduced resolution, although the range is still short in comparision to ASW-type systems.

Use of lasers as an underwater associate of sonar is still not too palatable. Range of these devices operating in the blue-green portion of the spectrum is believed to be limited to some 1,500 ft. under certain sea water conditions.

A laser has been mounted on the periscope of a submarine to test its effectiveness as a ranging device.

● **Refinements required**—Related to new transmission technique, industry officials also point out the need for improvements in the fire-control problem, particularly with active systems in which effective automatic target tracking gets even more difficult as higher-speed nuclear submarines join a potential enemy fleet.

The problem essentially is one of time. Acoustical pulses traveling through water move at a round-trip time equal to about 800 yards a second, which means that it takes some 50 seconds to make a round-trip pulse and echo from a target 40,000 yards distant.

Fire-control errors on the order of several degrees are not good enough, given the speed of nuclear subs and the weapons systems requirements. Systems on the order of a fraction of a degree error are believed necessary.

There are also other problems associated with new sonar developments. One is the need for better underwater test ranges where sonars can be more precisely calibrated. One contractor estimates that only a fraction of a degree of sonar error is caused by the acoustical path and that the largest portion is caused by hardware problems directly related to poor calibration and maintenance procedures or facilities.

Another problem one contractor privately reports is that testing of sonars aboard Navy vessels can be difficult at times, since the vessel remains under Navy control and conflicting and often unpredictable Navy-related assignments or problems can set back data-collection timetables aboard ship.

There is also a need for more precise instruments for accurate predictions of sea conditions affecting sonar performance. Bathythermographs are used, for example, to determine the depth to which VDS systems should be lowered, in addition to other measurements necessary for more conventional hull-mounted sonars to be properly calibrated.

Industry sources also say improvements need to be made in the type of sonar charts supplied to ASW crews. These charts, experts say, must include all modes of propagation now used by the fleet, and must also provide very important information on the propagation-loss fields associated with various areas. The job of interpreting current charts is also judged to be far too complex.

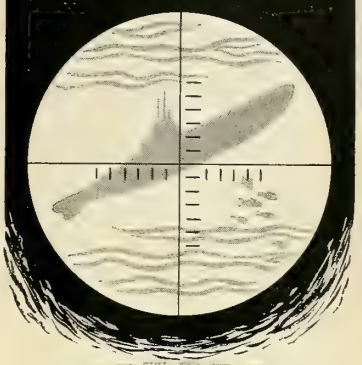
The oceanography problem cannot be separated from ASW. Knowing good and bad sonar operating areas and having accurate data of temperature profiles, salinity, and bottom characteristics are invaluable assets to a submarine commander.

● **Target classification**—The classification problem, that of determining what type of a target signal has been plucked from the incoming acoustical energy, has experienced a major increase in attention in the past two years that has paid off handsomely, say Navy and industry sources.

It is expected to continue to get even more emphasis as it becomes clear to systems designers that whatever gains in db can be made to improve a not very favorable signal-to-noise ratio are to be found in careful attention to the manner in which the incoming signal is received, processed, and displayed.

In the typical ASW problem, experts say that the signal level is virtually the same as the noise. The problem basically boils down to picking a patterned response out of the random noise. To do this, the Navy has made major inroads with new filtering and interference rejection schemes and has also sought to apply basic information theory to sonar with some success. Classified studies are under way in industry aimed

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at exploring the possible application of signal-processing techniques used in missile technology, radar, seismology, and optics to the sonar problem. Several of these techniques reportedly show some promise, and may lead to simpler means to accomplish these tasks.

● **Broader capability needed**—At the heart of the classification problem is the growth of the basic sonar sensor to cover larger volumes of water, return higher volumes of data, and operate at lower frequencies that eventually could take detection completely out of the sonarman's audible range. In addition, the reaction time of new submarines and weapons demand faster solutions.

To meet this, the Navy is studying several data "quantizing" approaches in which low-level signals are accumulated and recorded, and then the signatures are compared with a stored sonar signature profile.

Improvements in microelectronics and added flexibility of new digital computers are expected to speed this type of system into fleet use, although there are several questions left unsettled concerning the types of storage used and the extent to which optical data processing can be used rather than the solid-state digital techniques.

Use of a computer in a so-called classification sonar allows the system to look for clues in an incoming signal, evaluate them, compare them to a data base, and perhaps recommend changes in the mode of operation.

Navy officers stress that the entire question of accurate classification is still intimately linked to an improved understanding of the ocean environment, as it is in detection, particularly when using bottom-bounce. They also note that if the medium will support some of the new "special character" acoustical signals being studied, there may still be a few extra db left to somewhat ease the press for better signal-extraction methods.

● **Other classification aids**—In addition to basic sonar inputs, the Navy also uses certain ECM equipment and magnetometers for the classification solution. In addition to the BQQ-3 classification sonar already mentioned, at least two other new classification systems are under development.

One is the SQQ-14 underwater object classification equipment, which will be bought for the first time in FY '65. This is believed to be a surface vessel system. There is also a program known as "Aspect," which is not an acronym as so many of the ASW programs are, but actually refers to a "gadget," rather than a system, which can yield information on the aspect or attitude of a target.

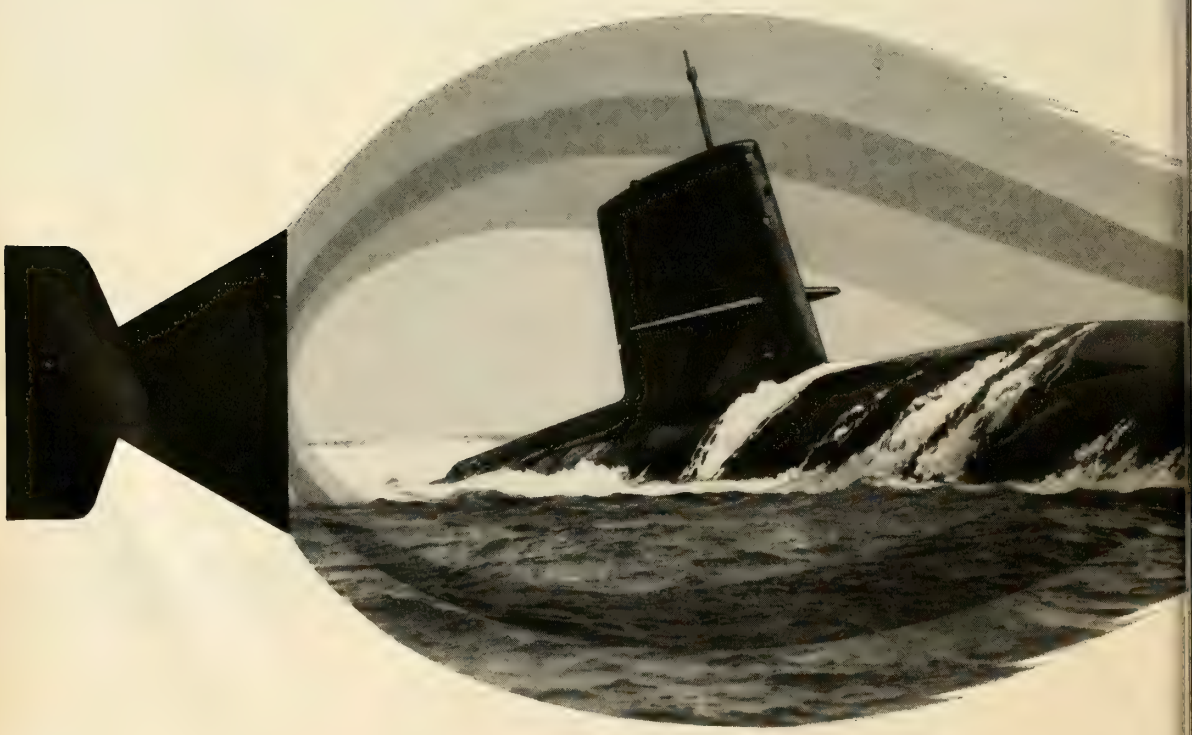
Airborne sensors also play a major role in the ultimate classification of a target (see page 54). Acting by themselves, however, ASW aircraft probably have the most difficult classification problem, according to observers, with the surface ships next and subs having the easiest task, relatively speaking.

The need for new and better training devices is also vital to improved classification competence.

● **Long-range listening**—In addition to its surface ship, submarine, and airborne ASW network, the U.S. has also embarked on an extensive program of long-range deep-water ocean surveillance using an assortment of both active and passive systems, usually in conjunction with fixed, bottom-mounted listening arrays.

The overall program for this type of surveillance has been given the code name TRIDENT. The program, begun in November, 1959, is actually the implementation of the Navy's Atlantis study, completed in March of the same year, which determined that this type of underwater surveillance was both technically and economically feasible.

Within TRIDENT, or growing out of it, there are currently believed to be at least three major programs: AR-



TEMIS, CAESAR, and COLOSSUS.

The ARTEMIS program, administered by the Office of Naval Research, has been described as an experimental R&D program using active detection schemes. The program includes an enormous 30-ton sonar transducer, built by Massa Div. of Cohu Electronics, Inc., which is carried aboard the USNS Mission Capistrono. It is lowered into the ocean via a well in the ship to gather data in combination with a large bottom-mounted array. The ARTEMIS program is still believed to be basically an R&D effort not involving procurement of operational hardware.

Using extremely high power, ARTEMIS operates in the VLF band of the electromagnetic spectrum. Its power requirements are estimated at the equivalent of those for a city of 50,000.

In 1961, before the project became even more highly classified, Navy officials testified that the ARTEMIS transducer has detected "everything that moved beneath the surface of the sea for 500 miles." There is little doubt that the system is being refined and considered for installation on the littoral of the U.S.

One Navy official, comparing ARTEMIS to such early warning systems as BMEWS and DEW line, advocates use of active coastal surveillance systems on the grounds that the enemy knows they are there, and if one is destroyed, it provides the same warning as though the enemy had attacked the U.S.

● **Rome and Greece**—The CAESAR program and COLOSSUS are both related efforts, the latter an extension of the former. They are both essentially passive long-range listening arrays, linked to ships and shore stations, and aimed at U.S. coastal surveillance and localization of targets.

Some $29.6 million is programmed in the FY '65 budget for "continental and ocean defense for the CAESAR program." However, budget testimony also reveals that $21.7 million of FY '64 funds related to the "extension of CAESAR" were held up primarily because of studies in the Defense Secretary's office, which indicates the program has undergone some change in emphasis or direction during the past year.

COLOSSUS is a longer-range version of CAESAR to be installed along the West Coast where the continental shelf is only about 20 miles wide. If the system proves effective, it will also be installed along the East Coast. The reason for the less urgent requirement for East Coast installation is primarily one of geology. The continental shelf in the East is 150 miles wide, which allows installations of a passive listening system at greater distances from the shore.

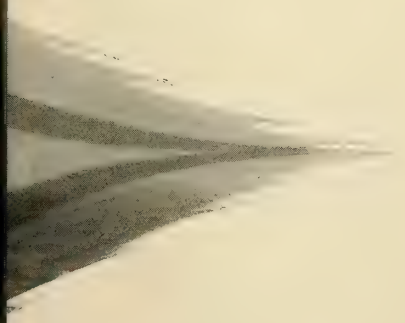
The Atomic Energy Commission is performing a study of the use of radioisotope power supplies for passive surveillance systems. One of the problems has been that the systems, linked by underwater cables, can be put out of commission if the cable is broken or fouled by underwater organisms. Atomic power would eliminate the cables and allow direct transmission of surveillance data to the shore.

Industry experts point out that even the decision as to how many hydrophones to hook up in an array is most critical in determining S/N performance, since collective hydrophone noise can mask a target.

While some undersea TRIDENT constructions have been made and some systems have been tested, the extent to which any of these systems have been put into operation is highly classified. TRIDENT has yielded vast amounts of data and is aimed at some operational status in the not-too-distant future.

The Navy is very keenly aware of the potential of fixed listening systems placed at the proper strategic spot to provide the vital initial clues to the

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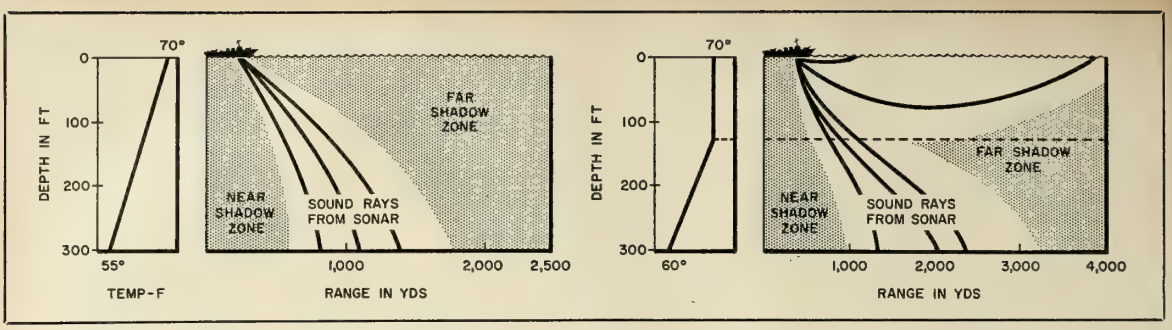
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LEFT: Diagram provided by Sperry Gyroscope Co. illustrates downward bending of transmitted sonar beam caused by gradual temperature drop as depth increases. RIGHT: Diagram shows effect of sharp drop in temperature resulting in a layer at 130 ft., which bends much of the beam back toward surface. Shadow zones provide hiding places for submarines.

U.S. surface, air, and sub-surface ASW force as to the extent and location of enemy submarine activity even in peacetime.

It is also well known where the Soviet submarine bases are and what bodies of water must be traversed for them to get to the open seas. Barrier systems strung across these routes are one obvious application. Another is barriers in the so called "light blue water" areas of the ocean, which would have the effect of forcing an enemy to operate in areas that Vice-Admiral John S. Thatch, Deputy Chief of Naval Operations, Air, calls a "sea of thick molasses."

The Soviets, faced with probably a much more severe ASW problem than the U.S. because of the immediate Polaris threat, have also recently boasted of development of "small radio-hydroacoustic buoys" located in the sea that can locate a *Polaris*-type submarine in the Arctic Ocean. USN sources regard the report as an exaggerated performance claim for a conventional sonobuoy (M/R, Aug. 24, p. 9).

• **Deep submersibles**—The Navy's program in the development of deep submersible vehicles could also play a part in deep-water listening, and possibly even the attacking capability of the future ASW force. While current subs can operate somewhere below 400 ft., experts believe this will go to a several-thousand-foot depth capability by the 1970's. A profile of the ocean depths reveals that about 20% of it runs to about 6,000 ft. and 85% to about 20,000 ft.

Deep diving vehicles, or DDV's, could conceivably aid in a number of tasks related to underwater fixed arrays, including site survey, construction, maintenance, and, very significantly, as target vehicles during checkout operations. Looking further into the future, some observers feel these vehicles would eventually lead to a second-generation deep-water surveillance system, which is mobile rather than fixed, and which removes the hazards to fixed systems once they are discovered, and possibly destroyed, by an enemy.

Operating from great depths as an ASW vehicle would also allow DDV's to take advantage of listening in the very deep sound channels through which LF noise travels even farther than in more shallow environs. Also, sonar-equipment devices would have a look-up capability and could probably operate even offensively against more conventional subs with relative immunity to counterattack or detection.

• **Airborne ASW**—Improvements in the Navy's airborne vehicles and onboard equipments will also keep the ASW aircraft as a vital member of the ASW hunter-killer groups.

The basic need for airborne systems has been and continues to be a good long-range radar-type detection system able to penetrate the water. Such a system remains to be developed, although very powerful electromagnetic transmissions can penetrate to very limited ranges.

The major progress in airborne systems will come via improvements in the range and power of the new sonobuoys and dipping sonars used, in combination with a vast increase in signal processing techniques, used to enhance the limited range sonar signals under development for the past five years. The best of these processing schemes are expected to be entering fleet use within the next 4-5 years.

One Navy expert says the airborne signal-processing problem has been hit so heavily that the latest systems in R&D are within about 5 db of the maximum that can be expected.

Firms such as Texas Instruments, IBM, ITT, and Bell Labs have contributed greatly in the application of new digital, statistical, interference rejection, and signal-mixing techniques applicable to airborne ASW.

Use of microelectronics will also make a major impact on the weight-conscious airborne systems.

• **Key airborne assist**—Within the airborne program, project A-new is probably the key effort. A-new is actually a management program aimed at putting together an integrated ASW avionincs system aboard an ASW-designed aircraft. The concept is basically to develop the best sensor package and data-handling system, and then write the aircraft specs around the avionics rather than the more traditional route.

The program got started in late 1960 and "has been funded by the Navy and blessed by DOD," says one official. More than $15 million has been spent in the past two years on the signal-processing and data-handling portions.

A-new, according to one Navy scientist, will reflect "drastic improvements in existing sonobuoys" in terms of increased power, and reduced size and weight. The system will include active explosive echo ranging devices, more commonly called JULIE, in which the return of the explosive signal reflected from a submarine is used as a detection method.

Both GE and Hazeltine are competing for new-type JULIE sonobouys, one of which will be bought for the first time for production in FY '65. The GE version is called the SSQ-46 and the Hazeltine, the SSQ-42.

Both are believed to be miniaturized to operate in conjunction with a new minibuoy dispenser now installed aboard the Lockheed P3A long-range ASW aircraft. There is also another member of the JULIE family, a directional device developed by Magnavox also slated for a FY '65 buy.

The other portion of the A-NEW sonobuoy mix is the JEZEBEL passive-type localization sonobuoy produced by General Dynamics.

The Navy is also known to be developing a new, much larger, and longer life air-dropped device called LOLITA.

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LOLITA-type—has been the development by steel companies of high-strength alloys that can be drawn to thinner gauges. These maraging steels have reduced the buoy weight considerably, since the cable assembly has always constituted the majority of the weight.

A-new will also carry magnetic sensors, a radar, and "a few sensors never seen before," using other physical principles. The Navy would not elaborate.

The Navy is continuing with Project Klinker, aimed at evaluating possible IR sensors able to detect temperature differences in the water caused by submarine passage.

While some success has reportedly been achieved, these devices are known to be susceptible to a number of sea state conditions that can easily obscure what is probably a very small temperature differential.

These devices are not believed to be operational now nor are they expected to be in fleet use soon, according to an informed source. The Navy does have a snorkel exhaust trail detector called SNIFFER in operational use. "The other so-called exotic sensors are not worth mentioning," says one Navy officer.

● **New radars**—The Navy is also known to be developing a new very-high-range and bearing-resolution radar-in-house which may become associated with A-new in the future.

The Navy views radar as a vital adjunct to the ASW problem, not only to detect snorkels, which is very difficult in heavy sea states and high radar-clutter situations, but as a means of sorting surface from sub-surface contacts reported by submarines or other sensors. In this capacity it serves as "a negative sensor."

The A-new system will first be tried out in the P3A aircraft. If it works, its designers feel they can then specify the vehicle that can best carry A-new. The effect of this testing could lead to modification of later buys of the shore-based P3A, which will probably be operational until the 1970 period.

Perhaps more importantly, A-new is very apt to lead to the development of a new carrier-based ASW aircraft to replace the venerable Grumman S-2 tracker series. Insiders say RFP's on a new VSX (fixed wing, ASW, experimental) are likely within the next year.

● **Helicopters**—Helicopter usage of A-new equipment is only a study at present, but could become part of a hardware program in the future, perhaps within a year. Many improvements in helicopter-borne sensors and processing and handling are now in R&D.

The Sikorsky SH-3A is the current heavy-weight ASW helicopter. This is a long-range all-weather craft capable of involvement in the entire ASW solution from detection through destruction. The Sea King, as it is called, carries a Bendix AQS-10 self-contained dipping sonar, which reportedly can be lowered beneath thermal layers. The craft now also carries the ASPECT classification device, a short-pulse means of classifying targets, which was originally developed for destroyers.

These helicopters also have improved precision navigation equipment for better pattern flying in a contact area and are used mostly in submarine screening and localization operations. They are said to have a good growth potential. They do not carry the ASQ-10 magnetometers in use on other aircraft, but officers say that MAD-type equipment eventually may be adaptable here.

The other helicopter in ASW use is the light-weight, unmanned, remotely controlled DASH, or QH-50C, made by Gyrodyne Co. of America. Some major problems with these devices were solved last year and the DASH is now operational, some aboard DD or DE types. A new landing assist system has been installed to aid operation from the destroyer deck in heavy seas.

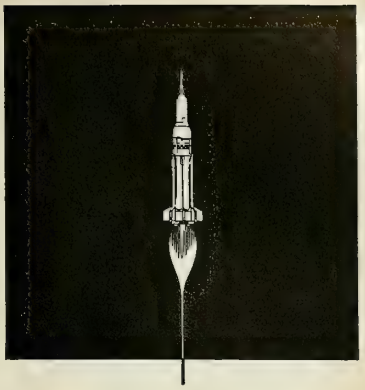
DASH is also meant as a device for quickly classifying a target, for verifying sonar contacts, and for reducing the possibility of false attack. New possibilities include passing control of the craft from one ship to another and for maintenance of very-long-range sonar contacts.

● **Satellites**—The Navy is also looking at the role of satellites for ASW roles.

As a mount for new and exotic sensors, experts believe that the satellite would not be able to see anything that an aircraft couldn't see better, though a Navy scientist told M/R "we have at least one company that would like to sell us one."

A satellite is more likely to be used as a monitoring device for a system such as a global array of somewhat more powerful sonobuoys. Satellite data collection from these devices and subsequent secure transmission is a distinct possibility for the future. The experts also note that an ASW mission aboard a satellite could be easily disguised. The equipment required would probably not demand a separate satellite. Satellite use for ASW navigation purposes is also likely. The Naval Research Lab is watching over most of the research in this area.

● **Communications**—Within the area of coordinating ASW operations between submarines and the other task force elements, there is an enormous amount of work to be done in the field of undersea communications.



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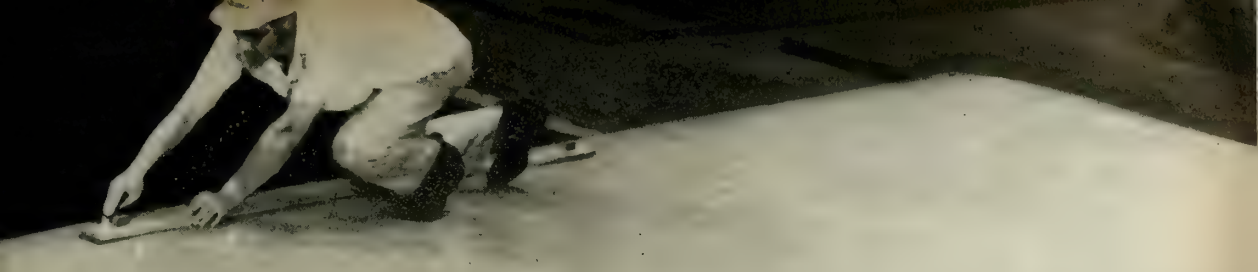
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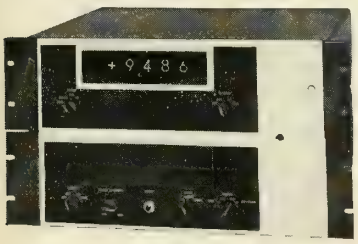
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While the Navy can use very-high-powered shore-based radio transmissions to communicate with its globally deployed fleet of *Polaris* submarines, the problem with submerged submarines engaged in ASW patrols or actions is very difficult. The sub-to-sub problem is less difficult than the sub-to-ship or -aircraft situation. There is a large pay-off here for industry, says the Navy, for new, workable systems.

Currently, most communications from beneath the surface are believed to be in the form of coded acoustical signals operating much in the same way as sonar, generally using separate equipment, and subject to all the attenuation difficulties and low-data-rate properties of the medium. There is also believed to be a good deal of pre-arranged signaling type operations.

One of the most promising advances in the past several years has been the development—and reportedly the type classification—of communications sonobuoys. These systems, dropped in the water, enable submarines to commmunicate with aircraft and more effectively with surface ships. Although Navy officials see this as an important advance, they still stress the need for reliable communications between all elements of the hunter-killer task force.

The submarine can also come near the surface to get an antenna through, but with some compromise in its position security. VDS can also be used for communications.

• **ADP needs**—The Navy's needs for increased use of automated weapons systems control are progressive and have, since World War II, trailed the state of the art slightly. As indicated earlier in this section, current data computation and processing requirements are more intimately related to software than to systems hardware.

Said one computer manufacturer: "We have the necessary computer technology and we can build the needed storage capacity to support systems, but the programming requirements for the future will be based on the kinds of input data that will be available. The biggest ASW need is in detection and it is difficult to amass comparative data now for use in sophisticated identification and classification analyses for use with future sensors."

The Sea Hawk program for development of an ASW surface vessel is now under renewed study, but subsystems development for such a ship is being continued. Included are advanced detection systems and the supporting automatic data processing systems for tracking and weapons control.

• **Fundamental data needs**—Even more basic than sensor needs for ASW support is the urgent requirement for a fundamental understanding of the sea environment from both local and global points of view.

The Office of Naval Research, following its earlier RFQ to industry, received proposals late in August for a program enveloping a massive data collection and study including a format for the ASW problem as an entity. An evaluation is due by mid-September and an early contract to industry is expected.

Heart of the effort will be the reduction and electronic massing of globally collected data, including both ship operations and operating environments, weapons delivery capabilities, and defensive techniques and capabilities.

At the same time, increased U.S. emphasis on oceanographic studies will begin to bear fruit. To help rectify what for years has been a lagging effort, scientists have turned to automatic data processing.

Typical of the trend toward greater ADP use is a jointly developed scientific shipboard computing system to be used aboard the Woods Hole Oceanographic Institution's research vessel, Chain. The system, built by IBM's Federal Systems Division and Woods Hole scientists, has evolved over the past two years from a relatively simple IBM 1710 computer system installed in July, 1962.

The system now includes a 1710 Model II with greatly increased memory, digital plotter, a digital feedback control system, remote displays, plus three separate magnetic disc storage units and input-output typewriters.

The point is not that such a system is available, but that a pure research vessel has had to be provided with such an improved capability. Used for real-time data acquisition and reduction of the Earth's gravity and magnetic fields, for dead reckoning navigation and for seismic profiles, it permits introduction of ship's heading and speed, latitude and longitude, water depth and depth compensation plus a multitude of other physical anomalies.

• **Central info center**—One apparent weakness in today's ASW program, say many industry informants, is the need for a central ASW laboratory and information depository.

Part of the problem, said one official, is the present Navy organizational structure. The carrier people, the helicopter people, the submarine people all go their separate ways—each fighting to preserve operational diversity within the realms of their own activities. Each has obtained an ASW role.

But, there is no single source in the Navy where one can go to obtain a clear picture of the entire U.S. ASW effort rapidly. Furthermore, said another industry spokesman, there may never be such a central depository for the problem of accumulating and classifying such data might be so big as to

negate its worth in the time required just to organize the central file.

● **Command and control**—The Navy Tactical Data System relies heavily on ADP but is not fully automated at the present time. Reaction time thus is limited by the introduction of man.

Some Navy officials, however, believe this is justified. They feel that over-emphasis on the use of automaticity may weaken the command-control function by denying flexibility in the decision-making process.

A natural outgrowth of the NTDS could be the increased use of force command ships. Individual vessels are now employing centralized command and control centers, highly computerized. The larger, more electronically equipped force command ships would serve as a central processing station and switching-central for the other combat ships. Such an approach may come to the fore as a means for controlling widely dispersed vessels in a fast reaction operational situation.

● **Training and maintenance**—As reliance upon computers and automatic processing grows for detection, tracking, navigation, and fire control, so does the ship's reliance grow on its operating and maintenance personnel. The Achilles heel may well be equipment malfunction and repair time.

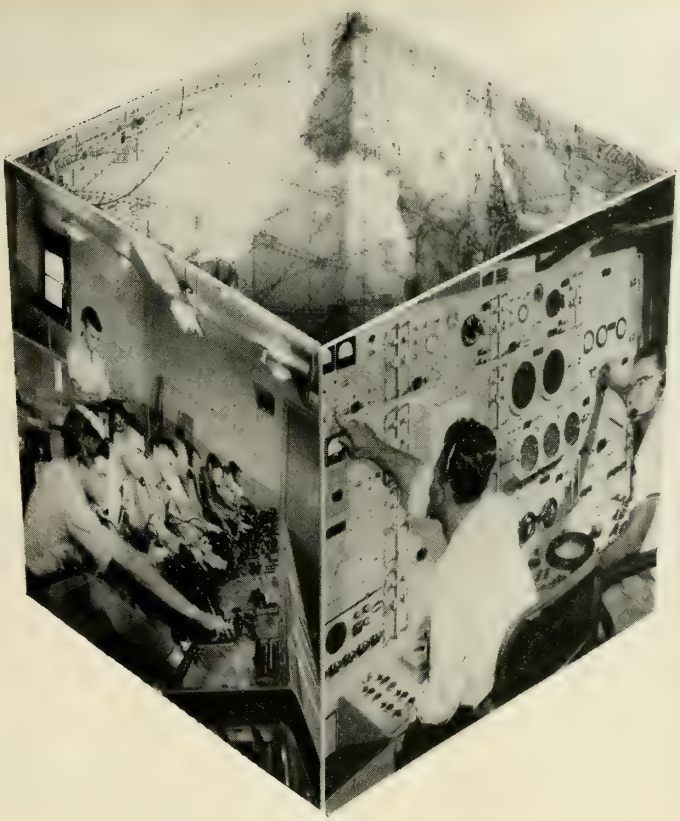
The former can be minimized by system or subsystem redundancy, but somewhere along the line an individual must locate and isolate a degraded or inoperable circuit, pull the offender and perform a hasty repair. When complete, the system must again work as designed.

Since lack of experience is the most serious handicap normally held by maintenance crews, the current trend is to simplify the repair problem. Automatic checkout helps, but it too is subject to failure.

Microminiaturization and replacement of defective parts at the module or subsystem level seems to offer the greatest return for simplified maintenance. Duplication of circuits—by the hundreds in computers—also eases the replacement supply problem. The trouble is, and will continue to be, that as circuits have become microminiaturized and as systems have become completely modularized, so has the need grown for larger capacity systems. Simplification has resulted in a complexity of a different sort and the pressure remains on the maintenance man.

Training of maintenance personnel, then, would appear to be the best means to improve electronic repair capability. It is often during the stress of an ASW operation that the pressure of time is the greatest. And, say many Navy officers, it is under such circumstances that personnel must be given the opportunity to increase their proficiency.■

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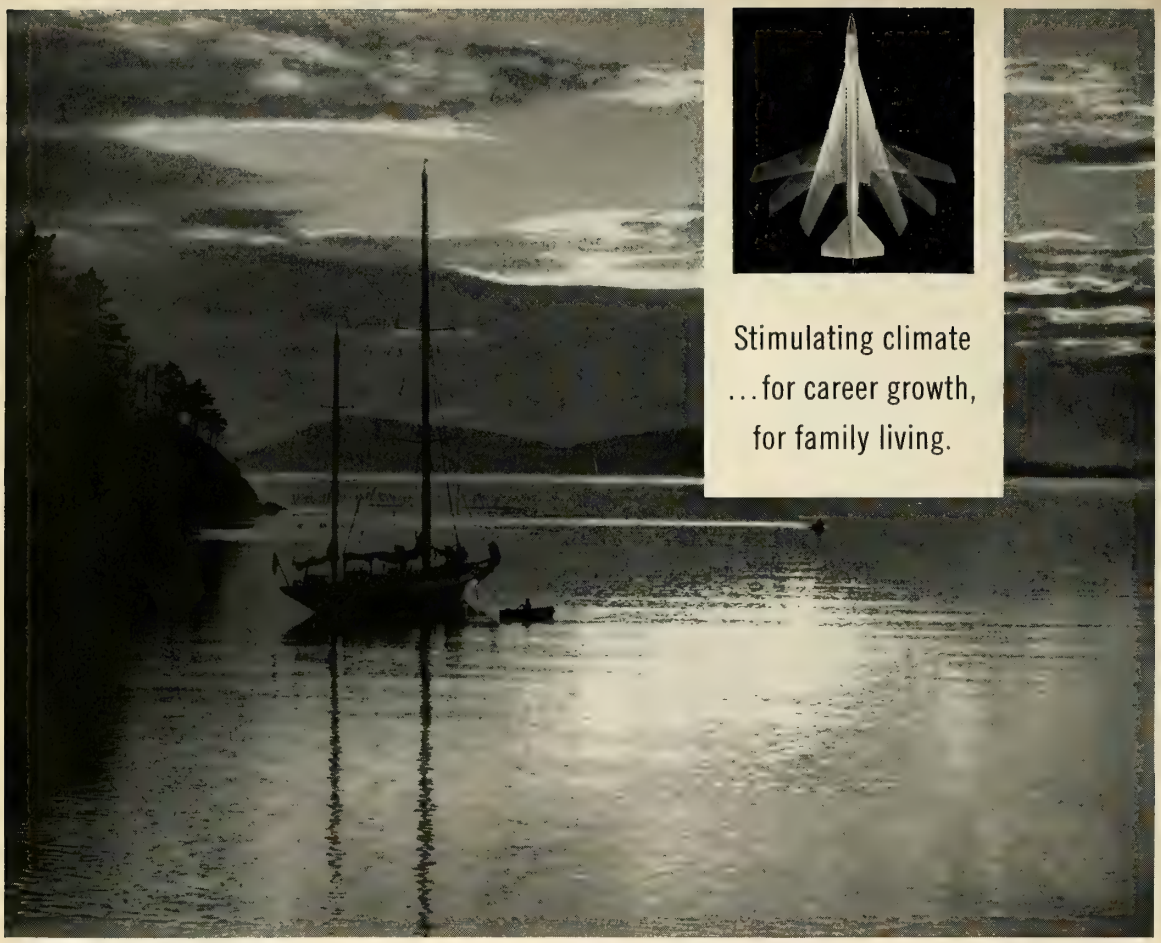
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Stand-off Weapon for Seahawk Ships Is Sole Big Missile Development Seen

Effort now is to provide conventional weapons that increase options; improved torpedoes believed able to handle present Soviet nuclear sub fleet; a review of current U.S. arsenal

A QUICK-REACTION, stand-off weapon for use with Seahawk, the integrated ASW ship, is the only major missile weapons development program on the Navy's horizon. A Honeywell *Asroc* with greater range has been proposed, but until the *average* sonar detection range increases, it is unlikely to be approved for development.

Major emphasis in Navy weapons is away from nuclear torpedoes, depth charges and stand-off weapons. Conventional weapons that increase the available options are the order of the day. Goodyear's *Subroc* poses a problem, since the only approved payload for this weapon is a nuclear depth charge. It is likely that an acoustic homing torpedo will have to be fitted to this weapon to preserve the non-nuclear option.

Navy officials admit that a conventional warhead for *Subroc* has been investigated and add that *Asroc* has demonstrated the technical feasibility of this approach. The primary problem is in the guidance of the missile, which would have to deliver the non-nuclear weapon with a greater degree of accuracy so that the target will be within the acquisition capability of the acoustic homer.

An EX-11 torpedo is also a development possibility. However, this replacement for the Mark 46, Mod 1, is in the early planning stages and the characteristics of the weapon are not fixed.

By and large, the Navy and industry are in substantial agreement that, of all the ASW problems to be resolved, kill mechanisms probably deserve less attention than any other. Weapons in fleet use and those already approved for development constitute a formidable arsenal. Among these weapons are: depth charges, air and surface and sub-surface mines, torpedoes, the destroyer anti-submarine helicopter (DASH), *Asroc* and *Subroc*. Over the next several years, these weapons will be improved, refined and made more sensitive to cope with the quiet-running, deep-diving high-speed nuclear submarine.

● **Torpedoes: a new world**—With the development of the Mark 46, Mod 0 and Mod 1, acoustic homing torpedoes have taken a major step forward, as, with initiation of development on the Mark 48, have wire-guided torpedoes. In fact, these two torpedoes are expected to be able to cope with the present generation of Soviet nuclear submarines, both in terms of seeking out the target and eluding countermeasures, and also destroying even the deepest diving, highest speed submersible in operation.

The Mark 46, Mod 0, is a replacement for the Mark 44 torpedo and uses active acoustic homing to close on its target. In relation to the Mark 44, it is faster, deeper diving and has a longer acoustic homing range. Propulsion is provided by a solid grain, which releases hot gas to drive the torpedo's engine. Development has been completed on the Mod 0 and operational evaluation is underway. A procurement contract for the Mod 0 has been awarded to its developer, Aerojet-General Corp.

The Mark 46, Mod 1, torpedo is under development. It differs from the Mod 0 primarily in propulsion—using a liquid mono-propellant rather than the solid propellant in the earlier model. Chief advantages of the liquid propellant, according to the Navy, are that the Mod 1 is both cheaper and easier to maintain. This propellant, representing an advance in the state of the art, was not available when the Mod 0 torpedo was being developed.

These torpedoes mark "an upward departure," one Navy official says, from the long plateau of acoustic torpedo development in terms of both acquisition ranges and speeds. Another Navy source points out that the sonar in torpedoes of this type is more effective than the sonar carried by destroyers in World War II.

The Mark 46 falls in the small, lightweight class of torpedoes—weighing 500 lbs. or less—which can be carried by aircraft and surface ships. The Mark 46 could replace the Mark 44 as one of the payloads for *Asroc* and would be a likely candidate for the non-nuclear version of *Subroc*. It could also be used on DASH.

In production and service use for several years, the General Electric Co.'s Mark 44 is a lightweight weapon for close-in attack. An active acoustic homing torpedo, the Mk 44 is powered by an electric battery motor. It is currently employed on Navy fixed wing aircraft, the HSS-2 ASW helicopter. *Asroc* and DASH. The latter carries two mark 44 torpedoes. There are still some of the old Mark 34 and Mark 43 torpedoes still in the fleet. However,

these are being replaced as rapidly as possible with the Mk 44.

• **Procurement question**—Eventual procurement of the Mark 46, Mod 0, is a delicate question in the Navy since there seems to be some uncertainty of the relative mix that should be maintained between it and the Mod 1. Currently, Navy officials will say only that they are procuring one and planning to procure the other.

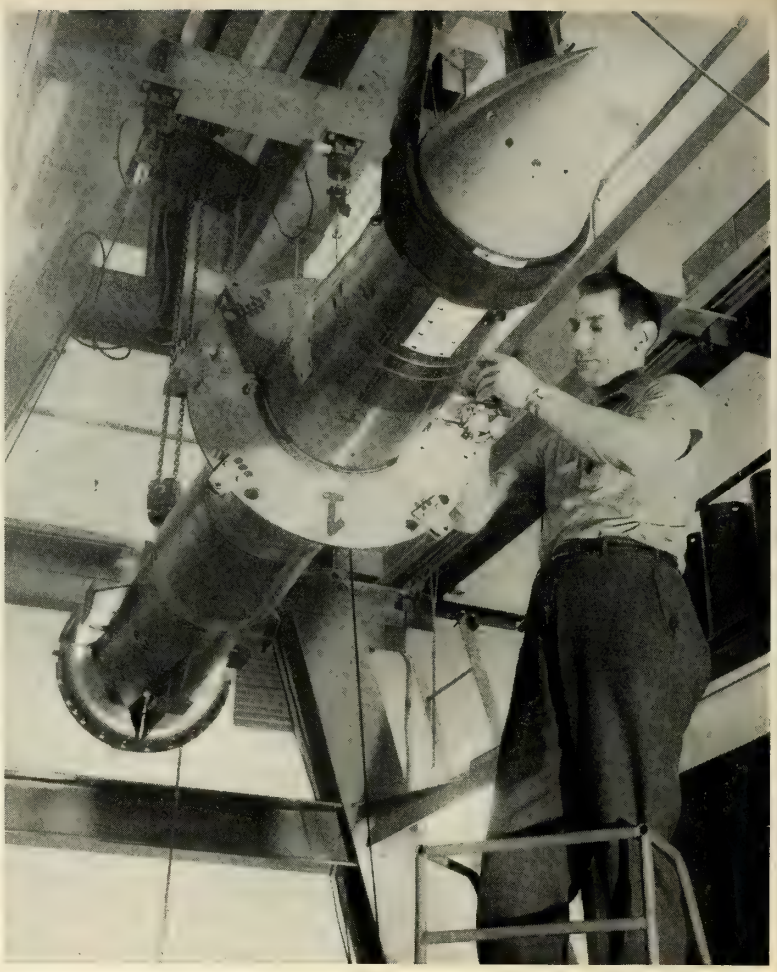
A second category of torpedoes are those larger, heavier weapons designed to be launched primarily from submarines and by some surface ships. These normally weigh in the neighborhood of 4,000 lbs. and carry much larger warheads.

The mainstay of the heavy torpedo class at the moment is the Westinghouse Mark 37 electrically propelled weapon. The Mod 0 version of this torpedo has either an active or passive acoustic homing device while the Mod 1 has a wire guidance system. All of the Navy's modern submarines are equipped with this torpedo where the older boats are still using the Mark 27, Mod 4. However, the latter is being withdrawn from the fleet as rapidly as possible because, in the Navy's opinion, the Mk 37 is "a modern torpedo." The wire guided version of the Mk 37 was developed by Vitro Laboratories.

Under development by Westinghouse now is the Mark 48—formerly the EX-10—torpedo to replace the Mark 37. Superior in all respects to the Mk 37, this weapon has "a much more sophisticated acoustic system" and is wire guided. It also uses a liquid monopropellant to drive the motor, and can be launched from submarines or surface ships.

All three of these torpedoes are armed with conventional, high explosive warheads. However, the highly classified Mark 45 torpedo—called *Astor*—carries a nuclear warhead. This long range, electric-powered weapon was approved for service use in Fiscal 1961 and initial production deliveries began in 1963. Presumably wire-guided, the 20-ft.-long, over-2,000-lb. torpedo has a range of 11 n.mi. Concerning its capability, the Navy will only say that it "is capable of destroying high-speed, deep-diving enemy submarines with high reliability. It can be carried by both conventional and nuclear powered submarines."

In the third category of torpedoes is the anti-surface-ship weapon. Although not properly an ASW weapon, the same techniques used in the ASW weapons are expected to be applied to this category. In fact, the Navy expects to begin development of a new, modern anti-surface-ship torpedo this year that will capitalize on all of the things learned in the ASW programs.



CENTER OF GRAVITY and moment of inertia on a Subroc missile are pinpointed with precise testing apparatus at Goodyear Aerospace Corp.'s Akron plant.

Although it is not in production, the Mark 39 is frequently listed as an operational Navy weapon. This is not the case, the Navy says. The Mark 39 was of the heavy, sub-launched class of torpedo and was the first wire-guided weapon of this kind. It was used to develop the technique of wire guidance of torpedoes in the early 1950's and, although a couple of hundred were produced, it was never considered as an operational weapon.

• **Problems overcome**—The golden age of torpedoes was ushered in with the perfection of acoustic and wire guidance schemes. The influence fuzes used in World War II "didn't work too well," according to a Navy official and it wasn't until the advent of the Mark 28 at the end of the war that the first acoustic fuze was available. This solved what until then was a major problem in torpedoes, that of active target maneuvering.

Today, although the ranges of torpedoes have not increased greatly, the volume of water searched (the true criterion for effectiveness) has increased by orders of magnitude. This makes target evasion extremely difficult.

In the area of countermeasures, Navy officials assert that they are "on top of the situation" in terms of both natural and manmade spoofers. There is considerable effort in this area, they say, but it is also the most highly classified subject in the torpedo area.

In order to stay abreast of technology, about half of the funds available in supporting research goes into the areas of acoustics, hydrodynamics, propulsion and general sciences. The portions of these efforts applicable to torpedo developments are pulled together in the RETORC I & II programs. RETORC, which stands for Research Torpedo Configuration, is a program of torpedo test vehicles—I for the small light-weight class, and II for the heavy, sub-launched vehicles. These research



GUIDED MISSILE frigate launches an Asroc at an "enemy" submarine during recent fleet exercises. Weapon eliminates need to attack at close range.

vehicles provide the reservoir of advanced technology from which periodically are drawn off techniques to fill weapons development requirements from the Chief of Naval operations.

The Naval Ordnance Test Station in Pasadena, Calif., is involved in the RETORC I program, while the Naval Underwater Ordnance Station at Newport, R.I., in cooperation with the University of Washington and Pennsylvania State University, handles the RETORC II program.

● **Mine warfare**—Although the stereotyped horned contact mine of World War I is still in the inventory and is still an effective moored system, mine warfare has progressed beyond this primitive defensive weapon. The use of mines in offensive warfare promises to play an important role, particularly against the Soviet submarine threat. Limited to two free-water ports, the Soviets must deploy through the Baltic straits or the Black Sea over through Arctic barriers. Such areas can be mined by aircraft so that a safe passage of water can become a death-trap within several hours. Approach routes can also be blocked by offensive mining or submarines can be channeled into kill areas by properly executed mine operations.

The basic goals of mine warfare are to damage or sink enemy vessels, to decrease the morale of crews aboard vessels that must traverse a mined area and to force the enemy to keep a large counter-measures force to counteract mining operations.

U.S. mines are all influence-actuated. That is, external influences such as pressure changes, magnetic fluctuations or noise level increases will activate the mine. In deep water, the mines are moored to the bottom, while in shallow water, the devices rest on the bottom.

Mines are classified by their modes of delivery: aircraft, submarine or surface vessel. In the aircraft-laid category are the Mark 52 and the Mark 55 bottom mines, which were first delivered to the fleet in Fiscal 1964. The Mk 52 is a 1,000-lb.-class mine while the Mk 55 is a 2,000-lb.-class weapon. The Mk 55 is an anti-submarine weapon. Another, 2,000-lb.-class moored anti-submarine mine under operational evaluation is the Mark 56, also launched by aircraft. This weapon would be effective against quiet, slow-moving submarines.

The rationale for the heavier, anti-submarine weapons is that the submarine is smaller than a surface ship and therefore does not produce as much signal. Also, the submarine is operating in a three-dimensional environment. Both of these problems complicate the development of mines and require heavier weapons.

Operational evaluation of the Mark 57 submarine-launched, anti-submarine moored mine was completed in late 1963. Quantities of the mine are being procured for fleet use.

Investigations are being conducted of an influence-actuated homing mine in both moored and bottom applications. Three new firing mechanisms are being developed to improve the effectiveness of present mines and to increase their resistance to countermeasures. These firing mechanisms will be backfitted to existing stockpiles of mines.

● **Stand-off weapons**—With the advent of *Asroc* and *Subroc*, the Navy has finally been able to free itself from the requirement of closing with the target to essentially zero distance. These weapons allow surface ships and submarines to stand-off at ranges comparable to their maximum detection range and kill an enemy submarine without closing with it. *Asroc* is replacing hedgehogs and *Weapon Alpha* as the primary ASW weapon of destroyer-class surface ships. *Subroc*, as long as it carries a nuclear warhead exclusively, will be a supplementary weapon for submarines—adding to the firepower of conventional torpedoes.

Asroc is a quick-reaction weapon capable of delivering the Mark 44 or Mark 46, Mod 0 or Mod 1, torpedoes to ranges from 1,800 yds. to 8n.mi. It also can be equipped with a nuclear depth charge. During the Dominic series of nuclear tests in the Pacific, the destroyer USS Agerholm successfully fired the nuclear version of the *Asroc*.

Although a number of ships entered the fleet equipped with the weapon in 1961, it was not approved for service use until 1962. Ships in the FRAM (Fleet Rehabilitation and Modernization) as well as new construction are being equipped with an integrated *Asroc* launcher. The overall length of the rocket-boosted weapon (torpedo plus booster) is about 15 ft. and the

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MAJOR ASW weapon is Westinghouse Astor torpedo, with nuclear or HE warhead.

diameter measures some 12 in. Overall weight is 1,000 lbs.

In addition to the possible development of a longer range version of *Asroc*, which is something, according to Navy officials, that can be achieved solely through use of improved propellant, a version of the weapon to be fired from *Terrier* launchers is being developed. This program is well along, the Navy says, and in "the not-too-distant future" it will be a reality. Basically, it involves a rail adaption to the *Terrier* launcher.

Subroc is a unique underwater-air-underwater, quick-reaction, standoff weapon incorporating an inertial guidance system in the booster to deliver its nuclear weapon. It weighs some 4,000 lbs., is 21 in. in diameter and approximately 21 ft. long. Its range, although not officially stated, is placed at 25-30 mi.

Development of the weapon was delayed for one year after the loss of the Thresher nuclear attack submarine in April, 1963. The Thresher was to have been the submarine used for the operational evaluation of the *Subroc*. Some unique test equipment for the weapon was lost in the disaster. Operational evaluation of the missile is expected to begin "in the near future," according to Navy sources. The USS Permit or the USS Plunger is likely to conduct the evaluation.

More than *Asroc*, the *Subroc* becomes involved in the question of weapons range versus sonar detection range. There is no question that, with advanced sonars, enemy submarines can be detected out to the maximum range of the weapon. However, this is still a factor of the environment existing at the time of the contact. Different conditions can produce contacts only at much shorter ranges. Therefore, the average detection range becomes a very important factor in determining the maximum range an anti-submarine weapon should possess. *Subroc* was designed with a specific sonar requirement in mind, and with more advanced acoustic equipment being developed, Navy weapons planners are investigating extending the range of *Subroc* in anticipation of a requirement for such a weapon.

Weapon Alpha now being replaced by *Asroc* was the first stand-off depth charge. The 500-lb. anti-submarine rocket is fired from a launcher resembling a gun turret to ranges of 1,000 yds. Destroyers, destroyer escorts and frigates are equipped with the depth charge. Some forward-firing hedge-hogs are still in the fleet and their effectiveness has been increased by the use of a plastic case for the propellant charge. An impact weapon, the hedgehog is fired in circular patterns of 24, and if one of the weapons explodes, the detonation triggers the remaining depth charges. The range of these weapons, however, is very short and requires, the attacking vessel to close with the enemy in order to make a kill.

• **DASH: quick response weapon**— After some vicissitudes in developing the unmanned gyrodyne, DASH, the system appears to be proving itself an effective extension of the striking arm of destroyers. Two of the DSN-3 helicopters are deployed on each ship, and each of these carries two Mark 44 torpedoes and eventually will be adapted to handle the Mark 46 in both of its

versions. Both the Atlantic and Pacific fleets are equipped with the weapon and eventually 80 destroyers will employ the unmanned helicopter.

At present, the Navy is working to extend the all-weather capability of the DSN-3 and to adopt new techniques for its use in the fleet. In the first area, new glass fiber rotor blades with integral heating elements are being tested as a solution to the de-icing requirement. Glass fiber will replace the wooden blades now used because of its strength/weight ratio and its greater resistance to weather erosion. In order to enable the DASH to operate in all weather, the Navy is also testing a Shipboard Landing Assist Device (SLAD). This is basically a cable extended from the hovering helicopter to the destroyer deck, which allows the latter to be winched down even in high-sea states.

Tactically, the addition of DASH to the fleet introduces new techniques for destroyer-submarine engagements. When the surface vessel receives a contact at long-range (15-20 mi.), it may have difficulty classifying the sonar return as a submarine. In this case, DASH can be sent out to cover the target and, if the contact is an enemy sub, it can be signalled to drop its torpedoes. Thus, DASH can shorten the time between classification and destruction. Also, important in an era when a torpedo can cost $400,000, it can improve, or lower, the false attack rate in which rather than take a chance a weapon is expended on a dubious target.

Additional techniques being tested by the Navy include passing the DASH helicopter-control off between widely separated surface ships, which could have the effect of spreading convoy protective forces out over a wider area and also allowing control of the unmanned system pass to an aircraft for vectoring to even greater distances.

Finally, the Navy is investigating the possibility of equipping DASH with a dipping sonar. This would allow the surface ship to investigate extremely long-range sonar returns by sending the helicopter out to first verify the contact and, when it is directly over the sub, to release its weapon.

A weapon the Navy does not talk about, but that is operational, is the air-delivered atomic depth charge—Lulu. Developed by the Naval Ordnance Laboratory and General Mills, this weapon gives an ASW aircraft a nuclear delivery capability and is regarded as an area defense weapon. There was an earlier model of this type of weapon, Betty, but it weighed almost three times as much as Lulu. With the greater effects of nuclear weapons in water, the accuracy requirements for delivery of the weapon are small and the range to the target once the weapon is in the water is of little consequence. ■

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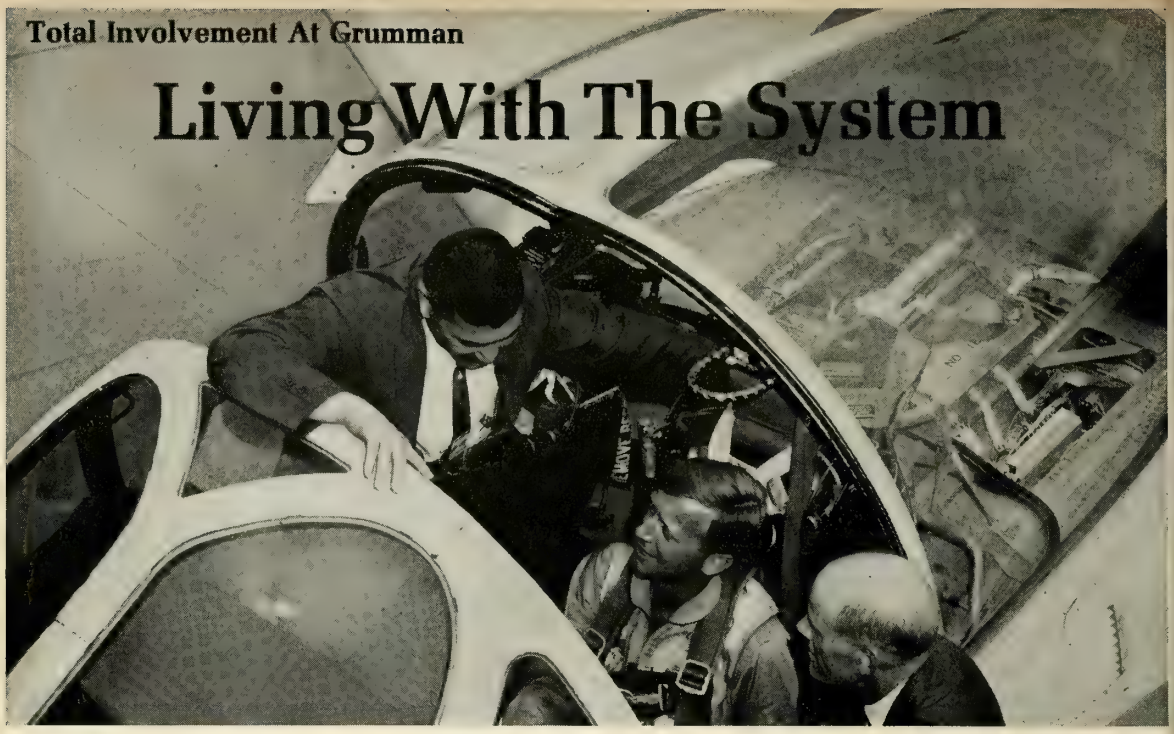
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Interest Grows in Oceanography Uses

One-third of Navy oceanographic budget aimed at strictly military goals; revised TENOC expected to stress hardware application

THE NAVY'S 10-year plan in oceanography calls for spending $1.315 billion within the 1963-70 period. This money does not include the cost of oceanographic work performed by other government agencies, but that may be of direct use to the Navy.

About one-third of the money the Navy is planning to spend is slated for research leading directly to military applications. This research falls into four major areas: acoustics, magnetics and gravity, Arctic operations, and environmental forecasting. About $480 million is involved.

The remaining $835 million has non-defense as well as defense implications. It is therefore considered not only a part of the Navy's program but also as a part of the country's overall effort in oceanography.

● **Fiscal 1965**—For oceanographic work in Fiscal 1965, the Navy asked Congress for $120.3 million, an increase of 12% over the $106.9 million requested last year. The Navy was finally given only $88.1 million for Fiscal 1964 as a result of Dept. of Defense cuts in the Navy's oceanographic budget as well as a Congressional cut in the Navy's Research, Development, Test and Evaluation (RDT&E) budget.

Reductions resulting from the Fiscal 1964 cuts were chiefly in the Navy's oceanographic shipbuilding program. In addition, the Navy cut back on procurement of modern instrumentation, survey operations of the Oceanographic Office, and contributions to the operations of the National Oceanographic Data Center.

For Fiscal 1965, the RDT&E budget was cut about three percent, but at this writing it is not yet known how this will affect the Navy's oceanographic budget.

Commenting on the reduction in oceanographic money for the Navy for Fiscal 1964, an Executive Branch agency said, "In the long run, the program may benefit from this decision because of the opportunity deliberately taken to evaluate performance of new ships already in operation or funded, before proceeding with construction of duplicates."

Continuing, the Interagency Committee on Oceanography (ICO) of the Federal Council for Science and Technology noted that by this delay there will also be opportunity to explore the emerging potential of such unconventional data-gathering tools as unmanned buoys, submarines, and FLIP-type platforms.

● **Who's in charge**—The Navy's research in oceanography is supported by five of its establishments: Office of Naval Research, Naval Oceanographic Office, Bureau of Ships, Bureau of Naval Weapons, and Bureau of Yards and Docks.

Their activities are coordinated through the Oceanographic Policy and Programs Board, the Oceanographer of the Navy serving as chairman. This Board is responsible for the Navy's participation in the overall national program in oceanography, as outlined by ICO.

For the current Fiscal Year, about 55% or $66 million of the Navy's program in oceanography is also part of the national oceanographic effort, which is planned and coordinated by ICO. The Assistant Secretary of the Navy (R&D) serves as chairman of ICO, whose eight departmental members represent 15 agencies engaged in the nation's oceanographic effort.

To coordinate so many diverse groups into a single group with a unified purpose is considered a unique achievement. This was affirmed by J. H. Wakelin, Jr., former Assistant Secretary of the Navy (R&D), who told the House Committee on Appropriations earlier this year, "To my knowledge, (this oceanographic effort) represents the largest scale effort that our government has yet put forth in expressing the unified plans of so many agencies over a 10-year period in a single scientific area."

● **Background of ICO**—This country in 1958 was spending less than $35 million a year for studies of the ocean, out of a national basic research budget of well over one billion dollars. Concerned that "this feeble effort thwarted fulfillment of their statutory missions," some of the federal agencies asked the National Academy of Sciences to look into the nation's oceanographic requirements and come up with a 10-year plan to help satisfy these needs.

On the basis of the Academy's subsequent report, the Executive Branch and Congress made a pointed effort to increase the country's support in the oceanographic field. The newly formed Federal Council for Science and Technology set up ICO in order to elevate the study of the ocean "from its comparatively primitive state of resources and activity to one in healthier balance with science and technology as a whole and more responsive to national needs."

As a result, the federal oceanographic budget grew from a Fiscal 1959 level of $32 million to $55 million in Fiscal 1960 and to $62 million in Fiscal 1961, with a budget supplement in Fiscal 1962 totaling $105 million. Partly as a result of Congressional action on the President's budget, the $124-million financing oceanography received in Fiscal 1963 leveled off in Fiscal 1964.

● **The ICO budget**—ICO's long-range oceanographic plan covering the decade 1963-1972 was approved in 1963 by the Federal Council. As a result, the current Navy oceanographic budget as well as the budget of other government agencies working in ocean-

ography are the first prepared with the objectives and recommendations of the long-range plan in view.

In an analysis of the national oceanographic program for Fiscal 1965, ICO says that even though the nation's current proposed oceanographic budget of $138 million "has been kept to a minimum consistent with requisites, there is, nevertheless, some proposed growth." This is in research, instrumentation and facilities components, which "form the cutting edge for scientific accomplishments (and) will grow from $68 million in FY 1964 to $86.7 million (in FY 1965), thus preserving the momentum already established."

ICO also identified a number of major program components deserving further study and emphasis: deep-sea research, and vehicles needed for this work; a more vigorous study of air/sea interaction; and a detailed rationale for future survey operations.

ICO is calling for approximately $2.3 billion for the 1963-72 period to be used for the national program in oceanography. As stated before, this money does not include some items of direct defense interest, which are financed over and above ICO's recommended budget. ICO hastens to point out, though, that much of the work it proposes is of high benefit to the Navy's defense mission.

At the same time, ICO does recognize and apportion part of its suggested budget for the nation's defense. This is the $845-million figure for the Navy mentioned earlier.

ICO gives the following relative financial emphases in the program forming its $2.3-billion long-range plan: strengthening basic science, 56% (more than half of this figure, or 36%; is also included in the rest of the detailed breakdown); defense, 36%; managing resources and health hazards in the world ocean, 19%; protecting U.S. public health, 4%; managing resources accessible to U.S. alone, 4%; contributing to the protection of lives and property ashore and safety of operations at sea, 2%; and finally, surveys and services to oceanography, 12%.

Yet, despite Administration and Congressional backing of a progressive national program in oceanography, the outlook is not as bright as ICO has hoped it would be. J. H. Wakelin recently complained that approval for oceanographic financing comes in bits and pieces from Congress. The reason is that a number of agencies must separately go before the legislative body for appropriations. Because of this, "the collective strength (the agencies) enjoy in the establishment of a national (oceanographic) program can be weakened appreciably by reduction of individual agency and department programs with the result that the entire effort suffers," he said.

He called this the major oceanographic problem and feared "it will lead to program stagnation." For instance, the Fiscal 1964 President's budget of $156 million was reduced to the Fiscal 1963 level of $124 million by Congressional committee action. Wakelin did not see the Fiscal 1965 oceanographic program faring much better.

He said that as more sophisticated instrumentation is developed, it also becomes more expensive to operate. Furthermore, education costs, ship operating costs, and salaries are still rising. Yet the oceanographic program is confronted by level funding. "In consideration of the potential involved, we consider this a most depressing outlook," said Wakelin.

• **Using the data**—"The Navy has been testing techniques for applying oceanographic data to operational problems for more than two years," Rear Admiral Denys W. Knoll, Oceanographer of the Navy and Commander of the U.S. Naval Oceanographic Office, told MISSILES AND ROCKETS. "The future of Navy oceanography depends on how rapidly we can apply our knowledge so that we can continue to predict phenomena that effect successful ASW and other submarine operations." He called for selecting techniques that have merit and collecting new data of a synoptic nature that "will permit us to handle dynamic problems, particularly as they apply to ASW."

Reflecting a similar view, Wakelin told Congress that the Navy over the next several years will continue to emphasize the data-collecting side of its oceanographic work. He explained that as the survey program, research program, and shipbuilding program for research vessels in oceanography come along in the next two years, "I think then we will be able to start consolidating the data for the Navy's own operational use." He pointed out that this is the end result of oceanography.

"We are not out to do scientific collection jobs *per se*," he said. "We are using this to learn more about the medium, and to apply it directly to fleet operations and ASW problems."

One "very important field" called out by Wakelin is deep submersibles, which is part of the Navy's extension of research work in oceanography. "We think we should get in the engineering phases so we are capable of operating at depths down to 1,000 ft.," he said.

• **TENOC 1963**—In 1961, the Navy first proposed a 10-year program in oceanography, called TENOC. This was revised last year but has not yet been released.

TENOC I, the first version, emphasized basic research in oceanography. TENOC II, expected to be ready shortly, devotes more time and money to the applications of oceanographic data. A high Navy official explained to M/R that when TENOC I was being made up, no one was taking a hard look at long-range sonar problems and their relationship to the ocean. "Now we are more systems oriented; TENOC II is trying to tie oceanographic research in closely with hardware development."

• **Problem areas**—ICO divides the national oceanographic research program into five problem areas, all of which the Navy is interested in for its ASW work: physical properties and motion of the sea; ocean-atmosphere inter-relationships; biological properties; structure and history of the ocean floor; and modification of the sea.

For contracts relating to the physical properties and motion of the sea, the Office of Naval Research (ONR) has a proposed Fiscal 1965 budget of nearly $9 million. The agency supports research through contracts with universities, research institutes, other government agencies and industry.

ONR reports that this budget will support an extensive program directed at obtaining time measurements of physical quantities in the deep ocean. Long-range telemetering buoys are being developed by the Convair Div. of General Dynamics Corp. Together with the necessary shore command stations and sensors, experimental buoys will be used by Texas A&M University, Scripps Institution of Oceanography, Lockheed Aircraft Corp., University of Wisconsin, the Navy Electronics Laboratory and other institutions.

In addition to current studies, other experiments will be undertaken to determine the energy spectra of internal waves both in the open ocean and in confined bodies of water.

The Bureau of Ships expects to spend about $2 million this year to continue its study of the distribution of sound velocities in the ocean. To this end, BuShips will use improved sensors mounted on oceanographic towers, surface ships, and the bathyscaphe Trieste.

The Bureau of Naval Weapons has asked for more than $2 million for Fiscal 1965 to conduct experiments "important to weapon system design, development, and prediction of systems performance." Some new oceanographic research ships will be used for these purposes.

Under this BuWeps program, the University of Washington Applied Physics Laboratory, using a deep-sea unmanned vehicle, will continue to study the horizontal variability of physical properties in the ocean. It is also reported that the Naval Ordnance Test Station, China Lake, Calif., will use a recently developed sound velocity-temperature-pressure measuring set to study the microstructure of physical and chemical properties.

One of the programs the Navy considers most exciting in the field of ocean-atmosphere inter-relationships is called ASWEPS, an acronym for an anti-submarine weapons environmental prediction system. This program, expected to be operational next year, will attempt to predict the state of the ocean, particularly for ASW commanders. This is analogous to weather predictions except it deals with factors such as ocean temperature, currents and salinity, all of which have a bearing on the ASW problem.

This work is not ICO-supported nor does it appear within the TENOC II projection. Instead, when it becomes operational, it will be funded by the Navy under its fleet operations budget.

Commenting on the problem of predicting the state of the ocean, a naval officer wryly observed how difficult, even with data from satellites, it is for meteorologists to tell what the weather is going to be.

ONR is planning to spend nearly $3 million this fiscal year on a program designed to take stereophotographs of the sea surface in an effort to determine ocean-atmosphere inter-relations. With ONR, the Naval Oceanographic Office and the Applied Physics Laboratory of Johns Hopkins University will jointly sponsor shipboard stereophotography to determine capillary wave spectra. Measurements of radar backscatter to determine the spectra of larger wind waves will be taken concurrently with aircraft stereophotography.

ONR will also be spending another $2 million to look into some of the biological properties of organisms in the ocean. In particular, the Navy is eager to understand the effects of biological organisms on sound propagation, to predict and control bioluminescence, to understand the mechanics of fish propulsion, and to understand marine animal communications.

In an effort to look into the structure and history of the ocean floor, BuShips through the Navy Electronics Laboratory and at the Lamont Geological Observatory, will back a program in geological-geophysical research with emphasis on problems of sound propagation applied to undersea warfare. Studies will also continue, under BuShips sponsorship, of geological structure, sedimentation processes and mass physical properties of sediments, by using the Trieste deep-diving vessel and other vehicles.

In addition, observational and instrumental techniques for obtaining information on the processes of erosion, turbidity currents, and sediment transport will be developed, according to a recent ICO report on the national oceanographic program for Fiscal 1965.

This report also underscores "an urgent need for underseas vehicles to provide an additional degree of freedom to oceanographic research." Reference is to the deep-sea research vehicle program, which ICO selected for special emphasis during Fiscal 1965.

Because oceanographic work is made up of so many bits and pieces, one of the big technical problems is how to assimilate and use the mass of data coming in. This is the work of the National Oceanographic Data Center, located in Washington, D.C., which is having a problem analogous to space scientists trying to reduce and digest satellite data. The Data Center, though, is working on automatic systems to help compile, process and preserve data in a form permitting rapid retrieval.

As with the ASW problem itself, the Navy is persuaded that there is no formula able to describe the ocean even in approximate terms. The best that can be done is to analyze statistically the major features of the ocean, their variability, and their effects on ASW devices. From this experience repeated in many ocean locations over a long period of time, patterns have and will continue to emerge to form the art of anti-submarine warfare. ■

Trailers by Dorsey for Link A3J-1 Trainer

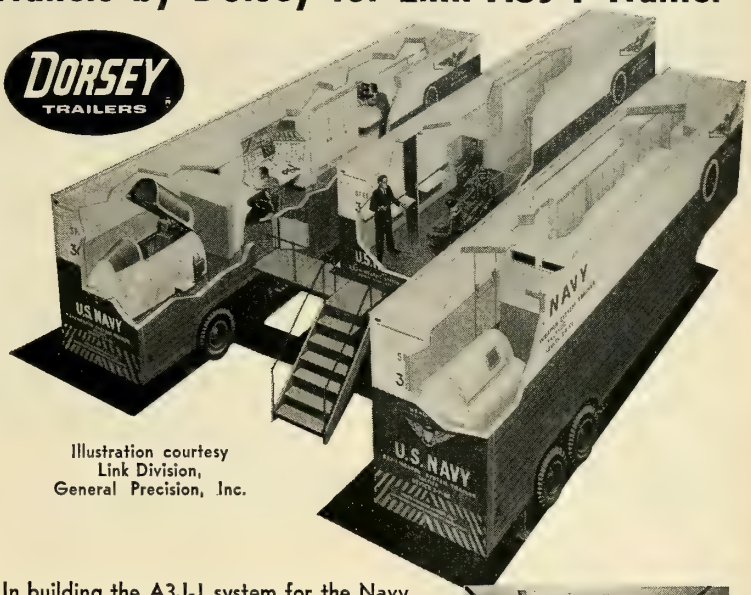


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Link Division,
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Propulsion Research Far More Secret Than Work in Related Materials Area

Space propulsion firms easily cross over into underwater activity; steel, aluminum, titanium and glass-reinforced plastics are all investigated for deep-submerging structures

TWO ASPECTS of the Navy's ASW efforts—underwater propulsion and materials—are closely related, but the activity in both areas is minor in comparison with the problems under siege in detection and identification.

Detailed information on the diverse programs of underwater propulsion, both primary and secondary, is highly classified. It is known that funds are going into this research area.

On the other hand, because the materials work is receiving relatively little Navy sponsorship, a great deal of information on this area is available. What is known indicates there is slight chance in the foreseeable future of any major construction program involving new materials and new approaches to ship construction.

● **Propulsion**—The similarities between underwater propulsion and its equivalent technology in space are striking—a fact demonstrated by the ease with which rocket propulsion firms have moved into both ASW and oceanography.

Chief among the many common points between rocket engine problems and those associated with deep submersibles is the high ratio of output power to system weight. Both weights and sizes are usually fixed in submersibles for any number of reasons. The problem is, then, to reach maximum efficiency.

External pressures imposed by varying depths should not appreciably affect the power output control. However, there is the difficult problem of providing propulsive power to a vehicle while preventing course detection.

The deeper such operational vehicles go—manned or unmanned, torpedoes or detection devices—the greater become the back pressures on propulsion systems. Concepts involving thermal direct exhaust systems operating at chamber pressures above that of the environment are being studied.

There are many heavily classified research efforts in this general area—ranging from uprated conventional propeller systems through high-energy rocket motors. As with the detection problem, no major breakthroughs can be anticipated. The route is through intelligent engineering compromises.

A second factor is the ability of the enemy to function at such depths. There does not seem to be great concern in the Navy about combating deep submersibles. There is a desire to operate in a military sense at these depths, but economic considerations and the lack of an immediate threat keep the programs at relatively low levels within the overall ASW effort.

The loss of the submarine Thresher pointed up the need to have at least a rescue ability below the collapsing depth of currently operational subs. The Navy is attacking this problem fairly vigorously.

There are no major materials programs directed toward surface ships. Most of the effort is confined to submarine hulls, with the emphasis on deep submersibles—both manned and unmanned.

Numerous materials are being considered for deep submersibles.

● **Steel**—The problem with steel is the low strength-to-weight ratios of currently available structural grades. There are development programs in plate steels with HY 150, 150,000 psi yield strength and also in the HY 180 and HY 200 steels.

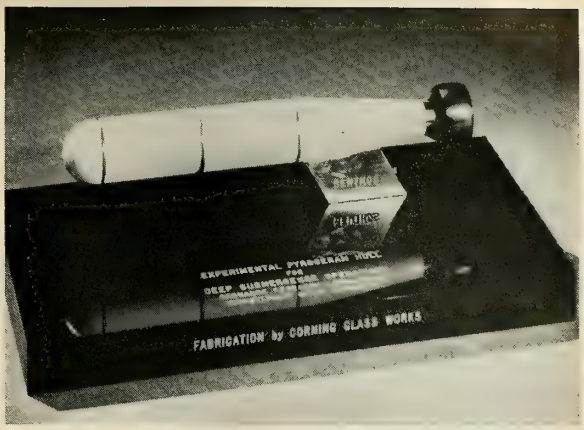
Low-alloy steels to 300,000-psi yield strengths have been fabricated but embody welding difficulties. These usually require extensive heat treating of the weld and heat affected zone to approach base metal properties. Notch sensitivity also increases with strength.

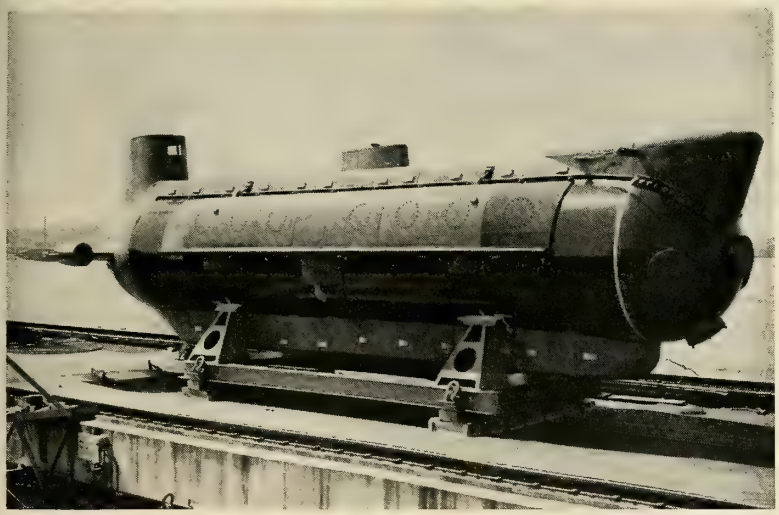
The class of 18% nickel maraging steels is being studied. These develop maximum strengths from a relatively simple heat treatment. Problems cited with this material are its high cost and relatively high notch sensitivity. Industry sources indicate this steel could become a prime candidate for deep-diving submersibles if it can be improved to lower its notch sensitivity.

Another class under consideration is the high manganese stable austenitic steels. These could become useful for submersibles if developed toward this end. They could be expected to give nearly 100% weld joint efficiency and are theoretically capable of strengths over 200,000 psi with good notch toughness to very low temperatures.

The manganese austenitic steels de-









TOP: Glass-ceramic sections similar to five-ribbed test units (left) will form part of hull of deep-submergence vehicle Benthos (right). Material has theoretical strength-to-weight ratio greater than that of currently used aluminum and steel alloys. BOTTOM LEFT: Aluminaut, an all-aluminum bolted-construction deep-diving submarine designed and built by Reynolds International Inc. Revolutionary sub is nearing first sea tests. BOTTOM RIGHT: High-purity alumina sphere developed by Coors Porcelain Co. demonstrates buoyancy in Colorado pool. Manufacturing/production techniques are established.

velop strength through cold working—an impractical approach for the welds of large structures. But certain metallurgical similarities of these steels in their lattice structure to aluminum and copper indicate a possible route to their potential high strength may be through precipitation hardening.

There is a trend toward development of a 150,000 to 200,000-psi yield-strength steel that can be easily welded. Development work is required on both the 18% nickel maraging steels and stable austenitic steels.

● **Aluminum**—The Navy has exhibited a strong dislike for bolted hulls designed to penetrate great depths. Thus, the main problem with aluminum is again welding high-strength alloys. A second problem is corrosion.

The 7079 grade of aluminum is thought to be one of the best alloys for deep-submergence. This alloy can be hardened to high strength levels in 4 to 6-in. thicknesses. But the alloy is not weldable as used in large structures and poses many problems in fabrication that can be handled only through the closest control of each step in fabrication.

Aluminum looks promising to depths somewhat greater than that obtainable with steel. For this reason, welding properties of high strength aluminum are being researched.

● **Titanium**—Probably the metal with the greatest potential for deep depth submersibles is titanium—but the welding problem is considerable. Unconventional designs and fabrication methods would have to be used to take full advantage of the metal's properties.

Once again the welding area is the problem, since it must be performed in a vacuum or with inert shielding gas. Developments in electron beam welding and portable vacuum chambers with walking seals may alleviate this.

● **Glass-reinforced plastics**—The major drawback here seems to be the requirement for an unconventional method of assembly. There are minor problems with creep and the action of salt water on the resin, which tend to reduce compressive strength after prolonged immersion.

From a strength-to-weight consideration, glass-reinforced plastic is the best material. But new methods of joining and bonding must be developed before its potential can be realized.

While all of these advanced materials appear promising for marine applications at great depths, their operational use in ASW is a long way off. There are hard research programs in being—the Aluminaut and the Dolphin being two examples. But both are considered to be research vehicles—especially the Dolphin. This vehicle will carry a 20-man crew while also generating structural data since its hull

will be highly instrumented.

The first major use of glass and ceramics as deep submergence vehicle hulls will come with the fabrication of the free-diving instrumentation capsule, Benthos.

Designed by experts at the Ordnance Research Laboratory of Pennsylvania State University, the Benthos will be the first in a series of glass-and-ceramic unmanned instrumentation capsules.

The projected depth capability is in excess of 30,000 ft., with a buoyancy better than 60% of the displaced water. Dr. J. D. Stachiw of ORL says only glass could allow the incorporation of so much buoyancy at such depths.

The length-to-diameter ratio of Benthos was selected to give the vehicle a payload range between 100 and 150 lbs. with a remaining buoyancy of 70 to 20 lbs. This buoyancy is thought to be sufficient to give the vehicle anywhere from 25 to 5-knot ascent velocity with its payload after ballast release.

● **Hull construction**—The hull consists of four glass-ceramic sections and one metal stabilizer, all locked together to form a monolithic pressure-and flexure-resistant structure using mechanical breech-type joints. The joint design locking mechanism is located inside the shell wall matching exactly the external surface and protruding as little as possible into the payload sections.

Corning Glass Works is making the hull sections out of Pyroceram Code No. 9606 glass-ceramic. The fabrication process consists of spin casting, induction of crystallization in the glass, grinding the interior ribs to size and fortifying the ground surfaces against crack inception.

The Pyroceram glass-ceramic was chosen because of its high compressive strength (greater than 300,000 psi) and since the material characteristically does not fail under compression. It actually gets stronger the deeper it goes.

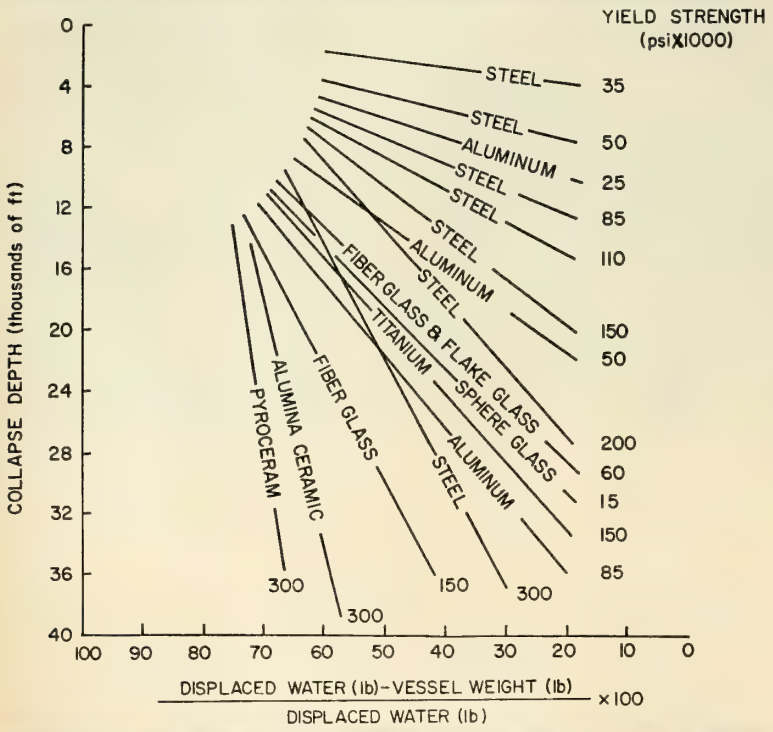
Corning specialists say the theoretical strength-to-weight-ratio of the glass-ceramic is higher than high-strength aluminum and steel alloys now used for underwater vehicles.

Various experiments tend to confirm this. H. A. Perry of the Naval Ordnance Laboratory tested glass spheres by lowering them to predetermined depths in the Puerto Rico Trench and then setting off explosive charges nearby.

Perry found that the bending load characteristic of the glass improved as depth increased 21,000 ft.—without reaching a maximum.

Stachiw tested spherical models of the Pyroceram glass-ceramic and found that at implosion, maximum compressive stresses were 364,000 psi.

And last year Corning Glass made glass spheres for a Coast and Geodetic Survey experimental undersea instrument platform that supported three anchor cables reaching 8,500 ft. to the ocean floor. The glass floats had a specification to withstand hydrostatic pressures up to 2,670 psi for a minimum of six months. Tests before use showed an ability to take several times this pressure for longer periods.



COMPARISON OF glass-ceramics (Pyroceram) with other deep-submersible materials collected by Dr. J. D. Stachiw of Pennsylvania State University.

● **Weldless aluminum sub**—The Aluminaut, an all-aluminum submarine capable of operating to depths of 15,000 ft., was launched Sept. 2 at Groton, Conn., by its builders, the Electric Boat Div. of General Dynamics Corp.

Conceived and designed by J. Louis Reynolds, chairman of Reynolds International, Inc., subsidiary of Reynolds Metals Co., the research boat hull is completely weldless. Eleven forged aluminum cylinders, each 40 in. long and 6.5 in. thick are held together with 400 precision aluminum bolts.

Two years of research at Reynolds resulted in the choice of aluminum alloy 7079-T6—a material with a yield strength of 60,000 psi in the thicknesses used. At a depth of 23,000 ft. the excess buoyancy is 31%.

The deep-diving craft is 50 ft. 11 in. long with an inside diameter of 7 ft. The Aluminaut displaces 150,000 lbs., has a cruising speed of 3.8 knots and a range of 80 miles. Its maximum submerged time is 72 hours.

The construction techniques and heavy-wall aluminum fabrication methods used represent a state-of-the-art improvement in such vessels. The Aluminaut represents a Reynolds investment of more than $3 million and five years of research, test and development.

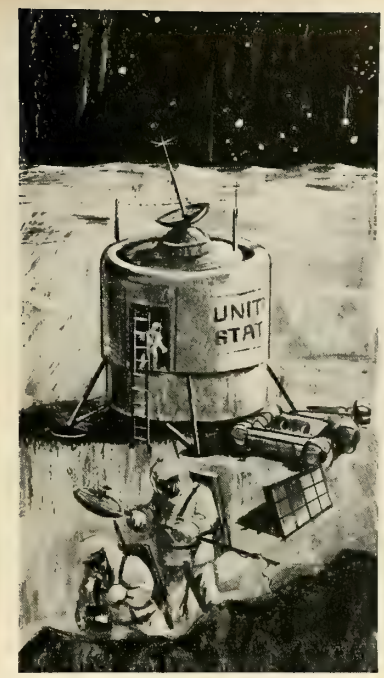
The Navy has exhibited considerable reluctance to move into bolted construction for manned undersea vehicles. The long history of successes with welding in such vessels may be difficult to overcome although Reynolds will soon take the crucial test with the Aluminaut at operational depths.

In addition, deep submersibles are not considered to be directly a part of the current ASW effort, but information gathered by such vehicles, manned or otherwise, will be used in ASW programs. ■

beyond apollo—
the U.S. space program

4th annual NASA issue

november 30, 1964



MISSILES AND ROCKETS, the weekly of Space Systems Engineering, will publish its fourth annual NASA Issue on November 30, 1964.

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New Undersea Test Facility To Go Operational in December, 1965

Bahamas site offers sheltered 'inner space' range for testing and evaluating Weapons, sonar and other ASW hardware; ITT gets systems management Job; British to share facilities

AUTEC—the Atlantic Undersea Test and Evaluation Center—will give the Navy an "inner space" range of incomparable effectiveness in evaluating ASW weapons and equipments.

For the first time, it will be possible to test to the limits of their design the performance of long-range weapons such as *Asroc, Subroc* and torpedoes and sonars ranging from fixed systems to dipping transducers.

Located 130 mi. southeast of Miami on Andros Island in the Bahamas, the $100-million AUTEC takes advantage of a deep water trench along the eastern shore of the island. This trench varies in depth from one fathom in the tidewaters to 1,000 fathoms throughout much of the range's length and breadth. More importantly, the trench—called the Tongue of the Ocean—is sheltered by the Grand Bahama Bank from the sounds and turbulence of the open ocean as well as from major ship traffic. The only navigable entrance to this 80-mi.-long, 20-mi.-wide *cul de sac* is a narrow channel which passes north of Nassau.

Thus, in AUTEC, the Navy has a realistic piece of ocean, operable almost all year around and environmentally protected from the disruptive influences of the open ocean. With the increased range, speed and depth capabilities of modern ASW weapons and sonars, the Navy has desperately needed such a facility.

Until AUTEC is operational in December, 1965, the Navy will have to continue to depend on the depth- and range-limited Dabob Bay test station at Keyport, Wash. This land-locked range has a length of only 6-7 mi. and a maximum depth of 600 ft. Although it is being improved, it will never be suitable for long-range, deep-water testing.

To overcome these disadvantages, the Navy has tried to test its weapons and equipment in the open ocean. However, according to a Navy official, these "jury-rigged attempts at open sea testing are expensive and the results obtained are not very good. But this was something the Navy had to learn the hard way."

So desperate was the Navy for a weapons test area that, during the protracted negotiations with the British and Bahamian governments for use of Andros Island and Tongue of the Ocean, it established an interim underwater tracking range as St. Croix in the Virgin Islands. This facility was needed for the operational evaluation of the Mark 46 torpedo, Navy officials explained.

● **A unique anomaly**—AUTEC, taking advantage of the very deep, sheltered basin off Andros Island, offers the Navy a research tool in which the technological base of underwater systems can be expanded indefinitely. However, should the demands on AUTEC exceed the capacity of the range, the Navy can expand into another deep-water trench—Exuma Sound—located only a few miles from Tongue of the Ocean. This sound is 100 mi. long and 40 mi. wide, with water 5,000-6,000 ft. deep. Closer to the open ocean and with more channels in and out of the sound, the area is less suitable than AUTEC site but still incomparably better than other deep-water areas surveyed.

● **3-D research tool**—AUTEC is a research and development facility, Navy officials emphasize, and will be concerned with such things as underwater acoustics, deep-ocean environmental effects on sonars, oceanography and development, and test of underseas transducers and weapons.

Feasibility of such a facility was proven in 1961 by Lockheed Aircraft Co., in a six-month study of the mission and requirements of an advanced test and evaluation center.

The underseas test and evaluation center will consist of three major ranges —an acoustic range, a sonar calibration range and a weapons test range.

The experimental and survey work has been completed for the acoustic range. Some of the sensors are already in the water and the rest to be installed within a year. The shore-based acoustic systems are being designed and the entire acoustic range is expected to be operational in two years.

The sonar calibration range is to be operational in two years, while only the launch and impact areas of the

weapons test range will initially be instrumented. All of the underwater sensors will be permanently emplaced and terminated in shallow water so that these test points are readily accessible.

The acoustic range will consist of range tracking systems, underwater communications, active and passive navigational aids and the noise-sensing systems themselves. In turn, these sensors will be instrumented to provide data on the hydrophone's depth and orientation as well as a leak detector to determine the system's status. Each sensor will be capable of being raised to the surface for maintenance.

The acoustic hydrophones are arranged on the bottom of the trench at fixed intervals and connected to a shore-based data-processing system. The arrangement of the sensors resembles a gridiron.

On this range the sounds produced by Navy systems can be measured and characterized. Thus, the Navy will have a valid index of the noise levels of both its surface ships and its submarines—important in the continuing program of ship-silencing.

• **Sonar range**—For the first time, the Navy will be able to evaluate completely the performance of its ship, submarine, dipping and variable-depth sonars. The importance of this was emphasized by an industry official who told MISSILES AND ROCKETS that not more than one-quarter of sonar errors can be traced to the environment. The hardware itself is the major contributor to the remaining error, he said, and poor calibration is a primary cause.

On the sonar calibration range, all aspects of sonar performance—source strength, receiver sensitivity, beam patterns, and accuracies—can be evaluated in all modes of operation, active and passive, and all azimuths. By measuring the system against a primary standard, accurate calibration can be obtained.

• **Weapons range**—The most complicated and largest of the three ranges, however, will be the Weapons Test Range. It will be able to test weapons in three dimensions—underseas, surface and in the air. A further unique characteristic will be its ability to track a variety of targets and, in a particular test, keep track of the attacker, the target and the weapon.

The underwater tracking system is the most complicated and will take the longest to develop since, according to Navy officials, it is one step beyond the state of the art. Radar systems for airborne and surface tracking will be the same as those used at other test ranges.

Although initially only the launch and impact areas will be instrumented, the Navy envisions an extensive data-acquisition and communications network over the entire length of the range, linked to a central data-processing center. With its own launch platform and motor patrol boats to transport weapons from ocean-going vessels into the range for test, the Navy foresees no need for capital ships to enter the weapons test area.

A pocketsize naval facility, located on Andros Island, will be used to modify weapons for test and to re-work weapons for additional tests. A Decca Mark 10 navigation aid will be used for precise positioning of the launch platform. The Mark 10 is not a general navigational aid but a precision system for very minute positioning of ships.

At the moment, there is only one officer, a representative of BuDocks, in the area. Eventually, however, the Navy expects to have 25 officers and 250 enlisted men stationed at AUTEC, with perhaps 50 transient personnel conducting tests. A small cadre of contractor support personnel will also be stationed on Andros.

• **Contractors named**—International Telephone and Telegraph Corp.'s Federal Labs in Nutley, N.J., was selected by the Navy on March 16 for "research, design, development, fabrication, installation and test of in-air and underwater tracking systems with their supporting data processing facilities" for the AUTEC complex.

Essentially, this means that ITT, under the $5,941,483 cost-plus-incentive-fee contract, will be systems manager for the project. The Navy will furnish much of the equipment, such as radars, power plants and machine tools, from surplus stocks and will procure directly from the manufacturer microwave and telemetry equipment which will be Government-Furnished Equipment (GFE) to ITT. In this way, the Navy expects to save 12% "off the top" of the cost of allowing ITT to directly procure the equipment.

On Feb. 6, the Bureau Yards and Docks awarded an $11,242,000 construction contract to Nat Harrison Associates, Inc., and Harrison Holding, both of Miami, Fla., for the initial increment of building on Andros Island and eight outlaying sites. Another $4,882,000 was earmarked in the '65 budget for further AUTEC construction.

The contract covers construction on the previously uninhabited island of main base structures—personnel quarters, operations shop, general storage, utilities and services and roads and fencing. Harbor facilities include ramps, bulkheads, a pier, rock jetties, breakwaters and turning basins. Construction is to be completed by early 1966.

• **Long history**—In August, 1960, MISSILES AND ROCKETS first revealed that the Navy was investigating the Tongue of the Ocean and Exuma Bay areas as the location of the AUTEC range (M/R, Aug. 1, 1960, p. 8). Subsequently, negotiations were started with the British for use of Andros Island, which had been bought some years before by the Admiralty. Negotiations proceeded to the point where, in 1963, it appeared that an agreement had been reached.

However, at that point the Bahamian government objected to AUTEC. Concessions had to be made to it before final agreement was reached. Announcement of the understanding was made on May 14, 1963.

Under the agreement, the U. S. is allowed use of the land for the center and the British Navy is allowed use of the facilities for testing its own ASW equipment or for joint testing with the U.S.

A special account has been established in the U.S. Treasury in which the British Government has agreed to deposit $420,000 a year for 20 years. This $8,000,000 can be used by the Bahamian government for the subsidization of loans from private U.S. interests.

The only major restriction on AUTEC is a specific exclusion that "no torpedoes nor any weapons of any sort with warheads" will be tested at the range. Excluding the political factors involved, Navy officials point out that explosions, over a period of time, would have a deleterious effect on the types of delicate instrumentation installed there—particularly the sensitive gridiron of bottom-mounted hydrophones.

• **Weapons test ranges**—With funds in the FY '65 budget, the Navy plans to begin acquisition of land for an underwater tactical range in the Pacific. Specifically, the range will be located off the coast of Lanai—northwest of Hawaii.

It will provide a tactical facility in the Pacific in which submarine weapons systems, sonar and fire control can be tested at full range. The difference between this range and AUTEC would be that this would be a tactical rather than an R&D facility, for operational readiness tests. During this fiscal year $4.1 million is expected to be spent as the initial increment in establishing the facility.

A range already in existence at Roosevelt Roads in the Caribbean is similar, except that it is an integrated facility in which both ASW and anti-air weapons can be fired. ■

contracts

Awards

AIR FORCE

$11,673,455—**Aerojet-General Corp.,** Sacramento, Calif., for the manufacture and delivery of second stage motors for the 6th *Minuteman* Wing.

$6,000,000—**General Dynamics Corp., Astronautics Div.,** San Diego, for additonal standardized *Atlas* space launch vehicles.

$4,000,000—**Marquardt Corp.,** Van Nuys, Calif., for continued research in advanced airbreathing propulsion concepts.

$3,000,000—**Aerojet-General Corp.,** Sacramento, Calif., for continued work in Azusa, Calif., on electronic equipment.

$2,947,850—**Collins Radio Co.,** Dallas, for continued production of high-frequency antennas for *Minuteman* missile installations.

$2,433,000—**Aerojet-General Corp.,** Sacramento, Calif., for R&D on the *Titan III* space booster.

$1,500,390—**Electronic Communications, Inc.,** St. Petersburg, Fla., for intermediate power amplifiers.

$1,252,500—**General Electric Co.,** Philadelphia, for continued work on a missile re-entry penetration study.

$1,000,000—**Anelex Corp.,** Boston, to produce printer systems for the interceptor control program.

$364,685—**Hughes Aircraft Co., R&D Div.,** Culver City, Calif., for research on advanced array techniques.

$260,000—**Midwest Research Institute,** Kansas City, Mo., for research on new bonding techniques leading to development of new and improved high temperature solid film lubricants.

$250,000—**Electro-Optical Systems, Inc.,** Pasadena, Calif., for high specific impulse thermal arc jet technology.

$85,000—**General Electric Co., Missile and Space Div.,** Phildelphia, for research on the friction and wear of materials under ultra-high vacuum.



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$80,000—**Aerojet-General Corp.,** Azusa, Calif., for research for exploratory evaluation of filament wound composites for tankage of rocket oxidizers and fuels.

$40,158—**Ling-Temco-Vought, Inc., Astronautics Div.,** Dallas, for research on the non-eroding thermally protective plastics and composites for hyperthermal environments.

$40,000—**TRW/Space Technology Labs,** Redondo Beach, Calif., for research investigation of refractory materials with regard to the effects of thermal shock.

$35,295—**University of Colorado,** Boulder, to study the nature of a vacuum.

$30,000—**Atlantic Research Corp.,** Alexandria, Va., for research on ablative plastic characterization on solid propellant exhaust.

$29,696—**American Potash and Chemical Corp.,** Whittier, Calif., for research on polyborophane laminating resins required for formulating high temperature structural polyborophane laminates.

ARMY

$1,999,000—**Northrop Corp., Ventura Div.,** Beverly Hills, Calif., for the production of MQM-57B surveillance drones.

$203,362—**Sperry Rand Corp.,** Salt Lake City, for engineering changes on *Sergeant* system equipment.

$167,000—**Carter Construction Co.,** El Paso, Tex., for *Nike-X Sprint* facilities, White Sands Missile Range, N.M.

$135,000—**Ralph M. Parsons Co.,** Los Angeles, for study/development of engineering services for log/support performance specifications.

$116,512—**H. E. Collins Contracting Co., Inc.,** Tullahoma, Tenn., for construction of service and support building and addition to J-4 control tower at Arnold Engineering Development Center.

$85,237—**Electro-Optical Systems, Inc.,** Pasadena, Calif., for gamma ray scanner instrument for rocket borne applications.

$59,799—**Martin Co.,** Baltimore, Md., for design, fabrication and delivery of three low-cost, velocity controlled rocket motor cutoff devices.

$53,237—**Sperry Rand Corp.,** Salt Lake City, for *Sergeant* repair parts.

$48,228—**Davies Construction Co.,** Montgomery, Ala., for construction of west area holding basin at NASA's Mississippi Test Facility.

$40,319—**Fairchild Stratos Corp., Space and Defense Systems Div.,** Syosset, N.Y., for design, fabrication and delivery of three low-cost, velocity controlled rocket motor cutoff devices.

$38,634—**Sperry Rand Corp.,** Salt Lake City, for *Sergeant* system.

$29,540—**Sperry Rand Corp.,** Salt Lake City, for concurrent repair parts for *Sergeant* missile system.

NAVY

$64,950,273—**General Dynamics Corp.,** Quincy, Mass., to convert and outfit three World War II tankers as tracking, command-control and communications ships in the *Apollo* program.

$9,583,334—**Vitro Corp. of America, Vitro Labs.,** Silver Spring, Md., for engineering services on the *Polaris* Fleet Ballistic Missile weapon system.

$4,448,941—**Radio Corp. of America,** Camden, N.J., for work on classified communications equipment.

$2,872,327—**Fairchild Camera & Instrument Corp.,** Clifton, N.J., for work on the *Terrier* missile program.

$2,580,000—**Missiles Systems Corp. of Texas,** Dallas, for production of retarding tail fins for the Snake Eye bombs.

$1,998,001—**Northrop Corp.,** Newbury Park, Calif., for production of surveillance drones.

$161,386—**W. E. Crawford Co.,** McAllen, Tex., for Raymondville, Tex., space surveillance station.

Vitro Corp. of America, Vitro Labs., Silver Spring, Md., for the training of two groups of engineers from the United Kingdom in the fundamental technical background of the *Polaris* Fleet Ballistic Missile weapon system (amount undisclosed).

ADVANCED RESEARCH PROJECTS AGENCY

$500,000—**Cornell Aeronautical Laboratory, Inc.,** Buffalo, N.Y., for continuation of its investigations of interceptor technology for ballistic missile defense as part of the Project Defender.

NASA

$11,480,113—**Hayes International Corp.,** Birmingham, Ala., to provide parts for launcher-umbilical towers to be used in outfitting *Apollo* Moon-flight spacecraft.

$4,200,000—**Grumman Aircraft Engineering Corp.,** Bethpage, N.Y., for equipment for White Sands, N.M., facility.

$1,000,000—**Beckman Instruments, Inc.,** Fullerton, Calif., and **Scientific Data Systems, Inc.,** Santa Monica, Calif., for an analog-digital computer system to simulate spaceflight conditions.

$500,000—**General Electric Corp.,** Philadelphia, for a gravity gradient stabilization system.

$235,000—**ITT Federal Laboratories,** San Fernando, Calif., for portable automatic calibration tracker.

$195,000—**Fairchild Stratos Corp.,** Bladensburg, Md., for an engineering model of an Advanced Solar Array.

$135,000—**United Aircraft Corp., Hamilton Standard Div.,** Windsor Locks, Conn., for experimental and analytical study of cardiovascular mechanism control loops.

$100,000—**The Boeing Co.,** Seattle, Wash., for a study of interplanetary mission support requirements for planned trips to Earth's neighboring planets.

$77,000—**National Research Corp.,** Cambridge, Mass., to extend ultrahigh vacuum gauge calibration into a new range.

$65,994—**Grumman Aircraft Engineering Corp.,** Bethpage, N.Y., for study of interaction of high energy gas molecules with solid surfaces.

$59,950—**Milgo Electronic Corp.,** Miami, Fla., for a digital data transmitter and digital data receiver.

$31,600—**Astrodata, Inc.,** Anaheim, Calif., for a solid-state decommutation system.

ATOMIC ENERGY COMMISSION AND NASA

$1,500,000—**Combustion Engineering, Inc., Air Preheater Co.,** Jackass Flats, Nev., to build an exhaust duct for a nuclear rocket engine test stand which will be part of the *Rover* program, a project to develop nuclear rocket propulsion.

NATIONAL SCIENCE FOUNDATION

$162,000—**University of Colorado,** Boulder, to Dr. Frank Oppenheimer for use in his study of the interactions of elementary articles—the smallest form of nuclear matter.

INDUSTRY

$1,000,000—**Firth Sterling, Inc.,** Pittsburgh, from **Aerojet-General Corp.,** Sacramento, Calif., to supply silver infiltrated tungsten components for rocket motors.

$700,000—**ITT Federal Laboratories,** San Fernando, Calif., from **The Boeing Co.,** Seattle, Wash., for navigational aids that will enable unmanned spacecraft to steer by a star.

$640,000—**Rantec Corp.,** Calabasas, Calif., from **Collins Radio Co.,** Dallas, for production of *Apollo* S-band antenna feed systems.

$260,000—**Microwave Physics Corp.,** Garland, Tex., from **Collins Radio Co.,** Dallas, for microwave equipment to be used in the *Apollo* Unified S-band Tracking System.

Philco Corp., Aeronutronic Div., Newport Beach, Calif., from **Space General Corp.,** El Monte, Calif., for manufacture of 170 valve units to provide missile roll control (amount undisclosed).

Menasco Manufacturing Co., Burbank, Calif., from **The Boeing Co.,** Seattle, for design and development of shock isolators for *Minuteman* control centers (amount undisclosed.)

—when and where—

Fourth Annual National Conference on Environmental Effects on Aircraft and Propulsion Systems, sponsored by the U.S. Naval Air Turbine Test Station, Nassau Inn, Princeton, N.J., Sept. 21-23.

Ceramic-Metal Systems Division Meeting, sponsored by the American Chemical Society, French Lick-Sheraton Hotel, French Lick, Ind., Sept. 20-23.

Applications and Processing of Fluorocarbon Plastics, sponsored by the Society of Plastics Engineers, Stacy Trent Hotel, Trenton, N.J., Sept. 22.

Techniques of Value Engineering for Defense and Space Contractors, a course sponsored by the National Defense Education Institute, Los Angeles, Sept. 21-25.

1964 International Symposium of the Professional Technical Group on Antennas and Propagation, IEEE, International Hotel, Idlewild, N.Y., Sept. 22-24.

Annual Meeting of the Digital Equipment Computer Users Society, Stratford House, Dayton, Ohio, Sept. 24-25.

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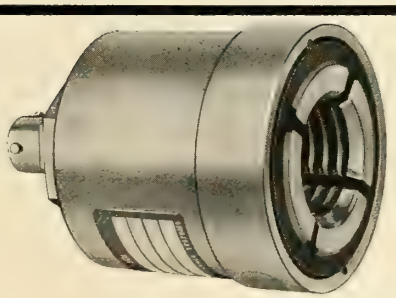
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Run Silent, Run Deep

THERE WILL BE NO easy solution to the problem of protecting the continental United States against the threat of Soviet submarine-launched missiles.

The very variety and complexity of elements in the anti-submarine forces—land, sea and air—are indicative of the difficulty of the task. The management problem of coordinating these various elements into an effective ASW system is in itself an awesome undertaking.

The House Appropriations Committee recently commented, "It may be that naval vessels, weapons and equipment will never be able to adequately defend the country against this threat."

When it is realized that in addition to countering Soviet missile-carrying submarines, the ASW forces also must be prepared to defend both merchant and naval fleets against enemy submarine action in either limited or all-out war, then the job which confronts those managing the nation's ASW effort becomes almost overwhelming.

For many years, in fact, the task has been regarded as so complex that no real effort at systems management has been made. The problem was surrendered to a bits-and-pieces approach which at one time saw as many as 54 separate organizations within the Navy directly at work on ASW. This diluted effort was being undertaken without benefit of overall long-range planning which would clearly define the problem, establish goals, set up priorities and coordinate hardware decisions.

Secretary of Navy Paul Nitze has moved to change all this. He views ASW as a prime, personal problem of his office. He is bringing to ASW the program package philosophy and the *Polaris*-type priority which it so long has needed. Systems management for ASW today is regarded as a necessity, not an impossibility.

To this end, the Secretary has handed to two professional career officers the task of bringing order to the chaos of ASW management. Vice Admiral Charles B. Martell, chosen not only for competence, but because he had no previous commitment to any single ASW philosophy, has been named director of the Navy's anti-submarine programs. Admiral Martell reports directly to the Chief of Naval Operations and to the Secretary.

Partner of Admiral Martell in ASW management is Admiral Constantine A. Karaberis. Admiral Martell sets the requirements. It is up to Admiral Karaberis, as head of the ASW Systems Project Office in the Office of Naval Material, to turn those requirements into hardware. A direct line of communications is provided between the two ASW admirals.

How grave is the threat of Soviet submarine-launched missiles, ballistic or otherwise? Latest figures show 142 missiles, both cruise and ballistic, carried by 30 Russian subs. Only a few of these submarines are nuclear-powered. There is no evidence as yet that the Soviets have accomplished an underwater launch. All their missiles must be fired from the surface.

There is confidence in the Navy that the W-class and Z-class conventional submarines which make up the bulk of the Soviet fleet can be handled by today's ASW forces.

But there is far less certainty about the Soviet nuclear fleet, even though their nuclear submarines—six of the early E-class with six missiles each are now in the Pacific and nine of the faster H-class with six missiles each are now operational and on station—are as yet far from comparable with the *Polaris* subs of the U.S. Navy.

Yet, it is tomorrow's Soviet threat which must be of concern to today's ASW planners. While the Russians are several years behind the United States in submarine development, it may be regarded as certain that they are at work on quieter, faster nuclear submarines and longer-range missiles with which to equip them.

The U.S. must be ready to meet this threat as it emerges. This means not only more sophisticated air and surface tracking equipment and weapons but also development of underwater tracking networks which are to their element what BMEWS is to the intercontinental ballistic missile. It means strong efforts to extend the detection and classification ranges which are so critical in underwater work. It means considerably more attention to basic oceanography to provide knowledge of the undersea environment. It means data collection and handling to an extent hitherto unknown.

IT MEANS A CHALLENGE to industry to bring to bear on these problems all the advanced technology developed in recent years. Although there is no evidence as yet that satellites will provide effective ASW surveillance or attack capabilities, they can serve as valuable communications and data relays. Microminiaturized elements developed for the space programs already are being used to improve ASW capabilities. Electronics engineers are turning their knowledge of the vast reaches of outer space to the problems of probing the dense depths of inner space. Although the Navy foresees no scientific breakthrough which will solve the ASW problem, this industry has the technology to push back many of the barriers once it is fully familiar with such strange names as Trident, Caesar, Colossus, FRISCO, Nutmeg, AUTEC, TENOC, PUFFS and Lolita.

No explosive growth in ASW funding is expected, but industry can find several areas of productive market interest. Secretary Nitze has made it clear he will welcome industry help in this field. The industry also must be prepared to face some cancellations of marginal programs as Admiral Martell attempts to bring direction to the present proliferation of ASW efforts.

The emergence of a strong, well-directed ASW program is a welcome change. It is, in fact, imperative if the nation is to counter a threat which can be expected to expand.

William J. Coughlin



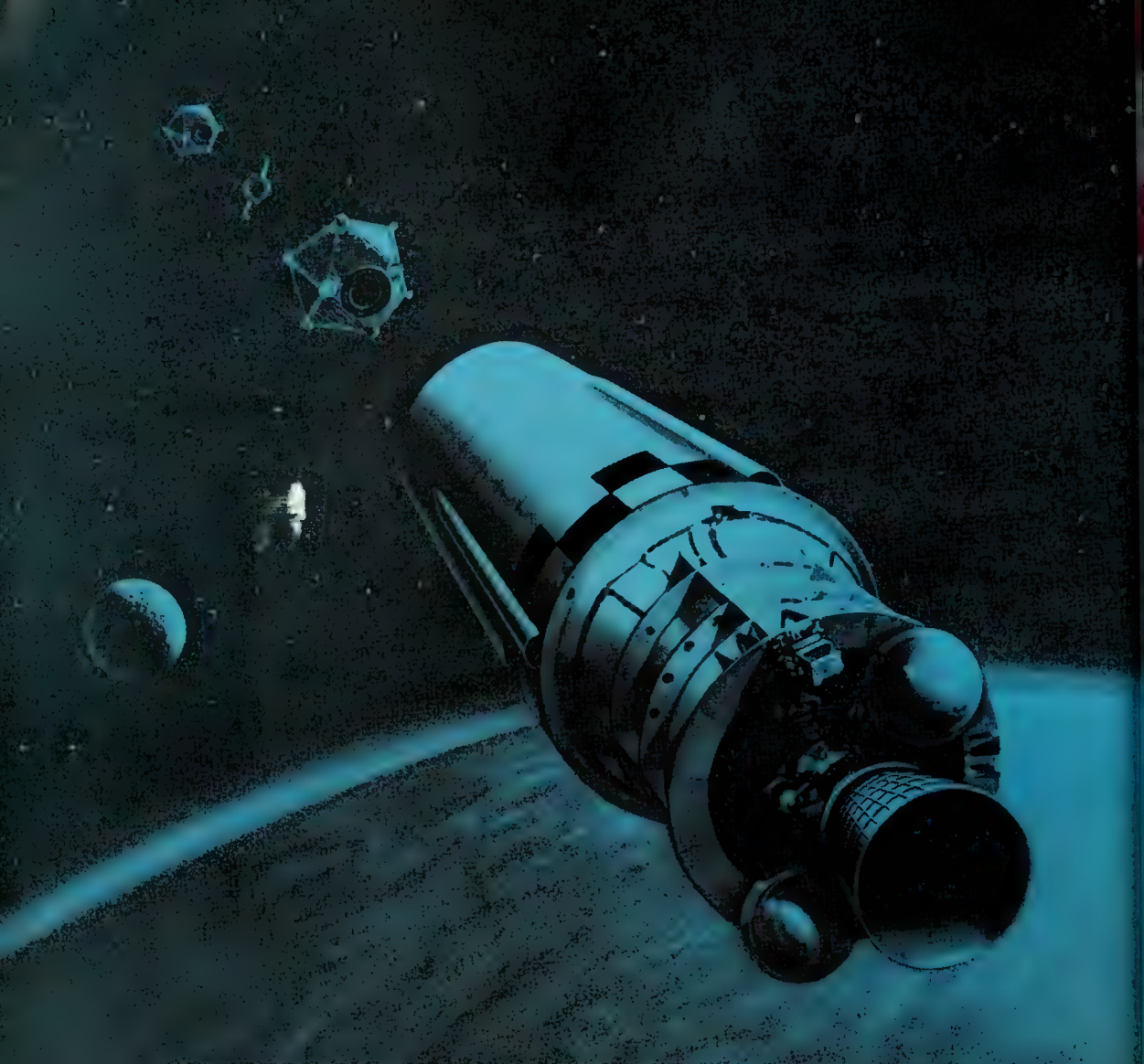
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America puts nuclear sentries in space

The successful launch of an Atlas-Agena rocket by the Department of Defense July 17 placed in orbit two experimental satellites equipped with X-ray, gamma-ray, and neutron detectors. Known as the Vela Satellites, their purpose is to provide data on the operation in space of nuclear test detection devices. ■ The two satellites, carried in tandem by a Lockheed-built standard Agena space vehicle, were placed about 100,000 miles apart in virtually identical near-circular orbits. ■ This was the second of several authorized launchings by the Department of Defense, each with two satellites designed and built by TRW Space Technology Laboratories and instrumented by the Atomic Energy Commission. The first two satellites, launched last October, have returned a large amount of data on radiation background in space, which will be used to design improved world-wide test detection systems of the future. ■ The precision required to position the twin satellites on their orbits made the reliable Agena the natural choice for this mission. Designed to meet the unmanned space requirements of the Air Force for several years to come, the Agena is also being used in several major programs of the National Aeronautics and Space Administration. More than 130 Agenas have been successfully launched to date. ■ Lockheed Missiles & Space Company, Sunnyvale, California: A Group Division of Lockheed Aircraft Corporation.

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missiles and rockets
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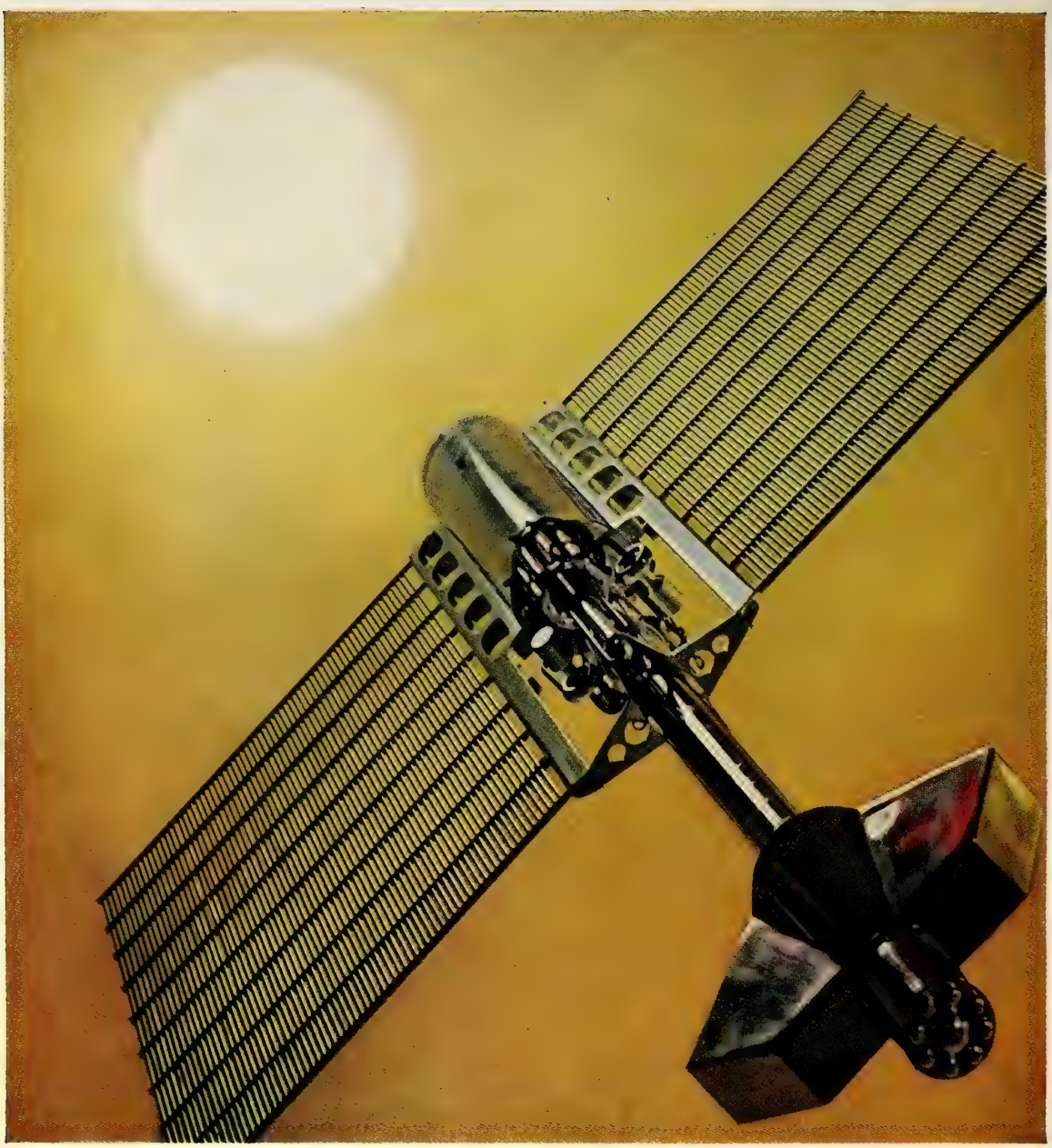
Anti-Satellite Development Far From Completion

NASA Geodetic Satellite Plans

Valveless Rocket Produced at RRC

Minuteman Shock Testing Slated

Rocket Research Corp.'s New Valveless Rocket



Nuclear electric power for a year-long space journey

Exploration of the solar system and power for manned satellites and lunar bases will require compact, long-life, nuclear-electric power systems.

Pratt & Whitney Aircraft is currently developing such a system for the Atomic Energy Commission at the Connecticut Advanced Nuclear Engineering Laboratory (CANEL) in Middletown, Connecticut. Known as SNAP-50/SPUR, it is powered by a high-temperature nuclear reactor cooled by liquid lithium.

The technology being developed in the SNAP-50/SPUR program will make possible other long-life, nuclear-electric powerplants for space, marine, and land applications — wherever compactness and low weight are essential.

Pratt & Whitney Aircraft DIVISION OF UNITED AIRCRAFT CORPORATION • EAST HARTFORD 8, CONNECTICUT

missiles and rockets

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Volume 15, Number 13 September 28, 1964

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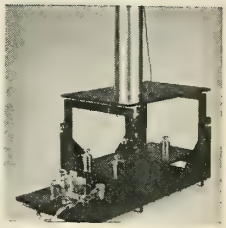
Published each Monday with the exception of the last Monday in December by American Aviation Publications, Inc., 1001 Vermont Ave., N.W., Washington, D.C. 20005. Cable Address: AMERAV.

Printed at Judd & Detweiler, Inc., Washington, D.C. Second class postage paid at Washington, D.C.
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Subscription rates: U.S. and Possessions, Canada, and Pan American Postal Union Nations: 1 year, $5.00, 2 years $8.00, 3 years $10.00. All other foreign: 1 year $15.00, 2 years $25.00, 3 years $35.00. Air freight to Europe: 1 year $20.00, 2 years $30.00, 3 years $40.00. Single copy prices: regular issues 50 cents each; special issues $1.00 each. Subscriptions are solicited only from persons with identifiable commercial or professional interests in the missile/space industry. Subscription orders and changes of address should be referred to Circulation Fulfillment Mgr., Missiles and Rockets, 1001 Vermont Ave., N.W., Washington, D.C. 20005. Allow 4 weeks for change to become effective and enclose recent address label if possible.

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THE COVER



Rocket Research Corp.'s prototype valveless solid subliming attitude-control rocket on compound pendulum micro-thrust balance. Microrocket has no moving parts, yet is capable of indefinite pulse cycles generating thrust. Highly sensitive balance has checked rocket. See story, p. 18.

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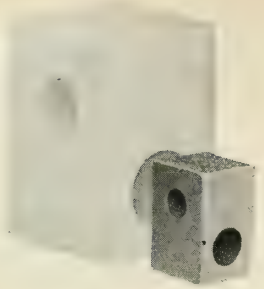
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THERE IS A NEW DIMENSION IN THE MEMORY MARKET

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Visit our MicroBIAX exhibit at International Space Electronics Symposium, Dunes Hotel, Las Vegas, Booth No. 82 October 6-7-8, 1964

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letters

Moon Craters Debate

To the Editor:

Reference "Letters," M/R, Aug. 31.

The editor states: "the smallest (3 ft. in dia. and 1 ft. deep) craters shown in the final *Ranger VII* photos would not be visible if the dust layer were more than a few inches deep."

Experimental evidence has proven the foregoing statement to be incorrect. Small rocks thrown out from volcanoes, as well as meteorites of varying sizes, can make craters in a deeply pulverized surface that vary in size from "pin-hole" to more than 3 ft.

Dr. Harold Urey and other highly qualified scientists have since stated that the *Ranger VII* photos were not conclusive as regards softness of the lunar surface or depth of dust, despite earlier contrary statements by NASA and JPL experts.

T. M. Morse
Santa Maria, Calif.

Controlling Controllers

To the Editor:

The logic inherent in John H. Bloomer's letter ("Why Organize Inventors?", M/R, July 27, p. 7) is commendable.

The universities are already in a state of perplexing anxiety concerning the built-up resentments of inventors and scientists who have been victimized. The featured article, "Taming of the Scientist?" on p. 7, Section 4, *New York Times* of July 26 stated: "Recent developments in genetics or molecular biology present social problems and possibilities for government control which even Hitler didn't dream about," and "Purdue University, MIT, Harvard, Princeton and the University of California are actively dealing with this problem toward 'a goal to meet the threat of power which could be held by irresponsible scientists.'"

The ability to invent is not within the teaching capability of universities; and as Benjamin F. Miessner pointed out in his letter "On the Mass Education of Scientists" in the July 1958 Proceedings of the I.R.E., the basic advanced-concept inventions of our civilization were and are made by "outsiders" not subject to control by universities proposing control of inventors and scientists as noted in the preceding paragraph.

Inventive ability is inherent in individuals in all nations, and there is no line of demarcation between strategic and non-strategic products. For example, in the field of molecular biology, which is causing anxiety as noted in the second paragraph herein, the breaking down of the tobacco mosaic virus into its separate inert constituents of nucleic acid and protein molecules is the starting point from which individual inventors and scientists in various nations can develop many different viruses that could be very destructive before vaccines can be developed to counteract them. It therefore appears that the major problem is that of controlling those who victimize inventors—rather than inventors.

Harry Bricker Fuchs
Farmingdale, L.I., N.Y.

Special Report on ASW

To the Editor:

Hearty congratulations on your ASW Special Report (M/R, Sept. 21)—surely the most definitive treatment of the subject that has been printed.

George Bauer
Philadelphia

STATEMENT OF OWNERSHIP, MANAGEMENT AND CIRCULATION REQUIRED BY THE ACT OF OCTOBER 23, 1962; SECTION 4369, TITLE 39, UNITED STATES CODE

1. Date of filing: Sept. 23, 1964.
2. Title of publication: Missiles and Rockets.
3. Frequency of issue: Weekly—every Monday with the exception of the last Monday in December.
4. Location of known office of publication: 1001 Vermont Ave., NW, Washington, D.C. 20005.
5. Location of headquarters or general business offices of the publishers: Same.
6. Names and addresses of publisher, editor, and managing editor: Publisher, James W. Claar, 607 Waterway Drive, Falls Church, Va.; Editor, William J. Coughlin, 1762 Church Street, NW, Washington, D.C.; Managing Editor, Reed Bundy, 534 6th Street, SE, Washington, D.C.
7. The owner is: American Aviation Publications, Inc., 1001 Vermont Ave., NW, Washington, D.C. 20005. Stockholders owning 1% or more of total amount of stock: Wayne W. Parrish, 2445 Wyoming Ave., NW, Washington, D.C.; James W. Claar, 607 Waterway Drive, Falls Church, Va.; Eric Bramley, 100 Morningside Drive, Alexandria, Va.; Fred S. Hunter, 1677 So. Westholme Ave., Los Angeles, Calif.; E. J. Stackpole, Harrisburg, Pa.; A. H. Stackpole, Harrisburg, Pa.
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10. (First figure in each category refers to average no. of copies each issue during preceding 12 months; second figure refers to single issue nearest to filing date.) A. Total no. copies printed (net press run): 46,966; 47,576 (9/28/64). B. Paid circulation: 1. To term subscribers by mail, carrier delivery or by other means: 44,010; 44,010. 2. Sales through agents, news dealers, or otherwise: None (no newsstand sales). C. Free distribution (including samples) by mail, carrier delivery or, by other means: 2,418; 1,928. D. Total no. of copies distributed (sum of B.1, B.2 and C): 46,428; 46,029.

I certify that the statements made by me above are correct and complete.

JAMES W. CLAAR
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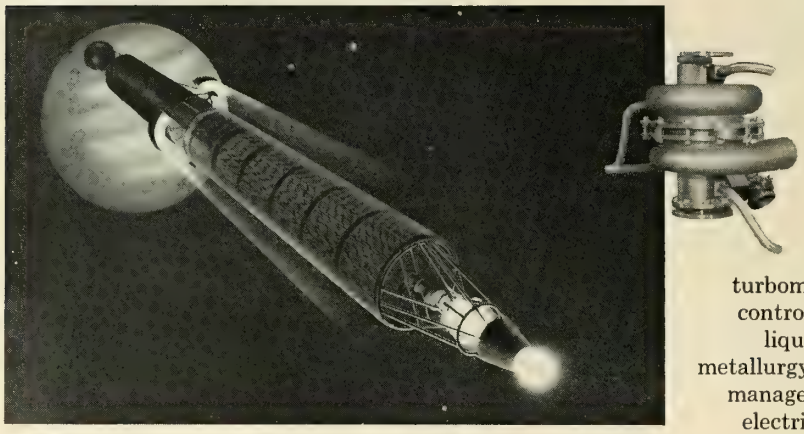


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North American Aviation Columbus Division

4300 East Fifth Avenue, Columbus, Ohio

It's possible that some people have never heard of a project called SNAP-50/SPUR. But they will.



Chances are this nation has never had a more challenging space project than this attempt to supply man-in-space with electrical power.

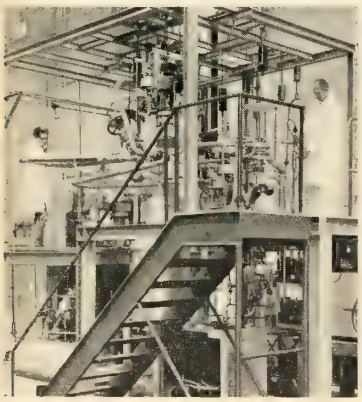
And that means enough electricity to provide a mission with *all* the power needed for space communications, propulsion, research, weapons and life support.

This is SNAP-50/SPUR.

It is a brilliant answer to some demanding questions:

How do you build a power station that must be a giant in output, but small in size and weight?

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The solution staggers the imagination.

Yet, such a system, designated SNAP-50/SPUR, is now being developed under the sponsorship of the Atomic Energy Commission and United States Air Force.

SNAP-50/SPUR will employ a nuclear reactor as a heat source to operate turbines that will drive electrical generators. Heat rejection and cooling is accomplished by a cylindrical radiator.

Working temperatures in the system are near that of molten iron. Here, conversion and rejection of heat demands the most advanced technologies.

Closed loop power conversion systems necessary for this kind of power production are being designed and tested by Garrett-AiResearch.

Garrett-AiResearch, with 25 years of experience in research and production of heat transfer, turbomachinery, control systems, liquid metals, metallurgy, thermal management and electrical power management has already developed much of the technology to be used in SNAP-50/SPUR power conversion equipment.

Today, in Garrett labs, turbines and heat exchangers are being operated with alkali metals at high temperatures.

Major components will be tested this year in Garrett's Phoenix facilities. Turbodynamic bearing tests (picture at left) are already in operation.

SNAP-50/SPUR is a rewarding assignment – actually the forerunner of future space power plants. Certainly, it demands unique capabilities. That's why Garrett is playing such an important role. Because . . .

Garrett *is* experience

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The Countdown

WASHINGTON

Apollo Engine May Be Retested This Week

First test firing of the *Apollo* spacecraft's Service Module engine at White Sands Missile Range on Sept. 22 was shut down after only one second, rather than the planned 10 secs. Officials of North American Aviation said malfunction of a ball valve in the propellant feeding system automatically stopped the firing. Another test may be made this week.

LEM Engine Contract Decision Deferred

NASA reports that no decision on a contractor for the *Apollo* Lunar Excursion Module's descent engine will be made for three or four months. Originally, the decision was to have been reached in July. Hence, the parallel development program will be six to seven months longer than expected—and more expensive by about the same ratio. The two firms engaged in the program are TRW Space Technology Laboratories and Rocketdyne.

Hypertension Study Slated for Gemini

NASA has awarded a $290,000 contract to the Texas Medical Center for a study of orthostatic hypertension. Sixty-six test subjects in groups of six will stay in bed for periods of three, seven and 14 days. Manned Spacecraft Center wants to get the data on the group prior to *Gemini-Titan 4 (GT-4)*, which calls for a three-day manned orbital flight in mid-1965.

Atlas Updating Beats Schedule by Three Months

Atlas F modernization program was completed Sept. 24 —nearly 100 days ahead of schedule—with 72 missiles at six U.S. buses returned to operational status. Program, managed by San Bernardino Air Materiel Area (SBAMA), originally was funded for some $100 million, but the Air Force said early completion saved "a substantial sum." Some 400 changes were made, 35% involving the missiles themselves and 65% support and launch equipment. About 3,500 engineers and technicians from SBAMA and General Dynamics/Astronautics took part in the program at Lincoln AFB, Neb., Schilling AFB, Kan., Altus AFB, Okla., Dyess AFB, Tex., Walker AFB, N.M., and Plattsburgh AFB, N.Y.

Revised Space Power Report Due Next Month

A joint NASA/DOD space power report will be presented for the second time to the Aeronautics and Astronautics Coordinating Board at its October meeting. An earlier report—presented to the Board in mid-year—was ordered revised because it did not concern itself with duplication in research among government agencies. Once the Board is satisfied, an unclassified summary report and 30 technical papers presented by government and industry experts will be published.

ABRES Shots Going West?

There's speculation at Cape Kennedy that two *Atlas* boosters which were to have been used to launch *Advanced Ballistic Re-entry System (ABRES)* vehicles from the Cape will be taken to Vandenberg AFB. Reason offered is that the better tracking available at Pacific Missile Range affords a tougher test of the re-entry profile. Five *ABRES* vehicles have been launched from the Cape. The move would leave Pad 11 empty and make it the apparent site for conduct of floxed-*Atlas* tests.

NOTS May Hover Rockets for Use as Probes

Naval Ordnance Test Station at China Lake is considering small hovering rockets as special-purpose probes for relatively low altitudes. For instance, they might be used to examine the edges of the fireball produced by a nuclear detonation. Or they might place proximity-fuzed warheads in the path of attacking aircraft or missiles. Key problem is stabilization. NOTS experimenters have made a rocket hover at the end of a tether, but a more sophisticated control system would be desirable. Because of the modest altitudes involved, air augmentation of the rocket motor is feasible.

INDUSTRY

Lockheed Set to Fire 156-in. Solid

Second firing of Lockheed Propulsion Co.'s 156-in.-dia. solid rocket motor is slated for Sept. 30 at Potrero, Calif. Test, conducted under Air Force contract, will have greater propellant weight, internal pressure, thrust and burn time than the first firing last May 28.

ERC Meets Some Diehard Opposition

About 50 businessmen who would be dislocated by construction of NASA's Electronics Research Center in Boston have banded together to oppose the center site before the city council. They claim the location is not a blighted area and therefore is not eligible for urban renewal funds. With a decision expected late last week, NASA was counting on council approval.

Neosho Hits 1,000 Mark in Big Liquid Output

The 1,000th large liquid rocket engine produced at the Neosho, Mo., plant of Rocketdyne was delivered to the Air Force Sept. 23. Engine was an MA-5 booster system for Standard Launch Vehicle (SLV-3) program. Delivery was made 6½ years after Neosho turned out its first engine, a *Thor*.

Marquardt Works on Waste Management . . .

Marquardt Corp. is developing an astronaut waste management system for NASA's Manned Spacecraft Center. Program is expected to yield a system capable of processing waste output of four astronauts during a 14-day mission, with potential of one-year operation. Distillation is employed, with wastes boiled at low temperature and pressure to provide potable water.

. . . And Aerojet Explores Water Conversion

Aerojet-General will investigate possibilities of applying to spacecraft its reverse-osmosis process for converting waste water into fresh. Company is now operating a pilot plant under contract to U.S. Dept. of Interior.

INTERNATIONAL

Japan Plans Buildup of Hawks and Nikes

Japan's Ground Self-Defense Force is asking $23 million in its Fiscal Year 1965 (April, 1965-March, 1966) budget to beef up its missile forces. It plans to build up its *Hawk* contingents and expand the number of *Nike* units.

The Missile/Space Week

NASA, AF To Swap Personnel

NASA and the Air Force have signed an agreement calling for the exchange of scientific and management personnel.

Previously, no NASA personnel have been assigned to the Air Force. There are, however, about 100 Air Force officers now on duty with NASA under an earlier pact signed in 1959. About 40 more senior Air Force officers are scheduled for space agency assignments in the near future.

Primary purpose for the new agreement apparently is to aid the Air Force's fledgling manned space flight effort by enabling that service to obtain experienced NASA officials on a temporary basis as well as permitting Air Force officers to serve in key or middle management level jobs in Projects *Gemini* and *Apollo*.

NASA officials assigned to the Air Force will be in the GS-13 and above level. Air Force officers slated for duty at NASA normally will be majors or higher in rank. Lower ranking officers with specialized technical skills may be assigned to NASA in positions offering exceptional training opportunities.

NASA has agreed to request officers for only those positions requiring education, experience or skills especially developed by the Air Force in the fields of technical program management, engineering and physical or life sciences, but only after NASA has made a reasonable effort to fill these positions from civilian sources.

Civilians selected from NASA will be from the following five areas: aeronautical and aerodynamic sciences; astrophysical and space sciences; aeromedical and physiological sciences; communications, tracking and launch site technology; and spacecraft and launch vehicle technologies.

The assignments of NASA personnel to the Air Force generally will be for two years.

Martell Tells of ASW Efforts

Vice Adm. Charles B. Martell, director of Navy anti-submarine programs, has answered with an "unequivocal yes" the question of whether U.S. ASW forces can presently cope with Russia's nuclear powered subs (see M/R special report on anti-submarine warfare in Sept. 21 issue).

He told a press conference last week of the Navy's increasing concern with the threat posed to U.S. shipping and naval operations by Soviet submarines, however, and said, "The problem will continue serious as long as the Russians keep building submarines at the rate of seven to ten a year." He then outlined for reporters the Navy's program in the ASW field.

Nimbus I Stops Operating

The *Nimbus I* weather satellite ceased operating on Sept. 23 after 380 orbits of the Earth.

The satellite, which had transmitted 27,000 weather photos back to Earth, shut down after its solar panels locked and could not be dislodged. Since the solar panels could not be rotated toward the Sun, the satellite's batteries could not be recharged.

The locked panels were caused by the build-up of several days' friction in the motor that turned the solar panels.

Space agency officials reported that *Nimbus* was a success despite the technical deficiency.

They said the satellite had taken remarkably good pictures of hurricanes and tornados as well as the first cloud cover pictures ever made at night.

It also took a midnight picture with its infrared cameras over Antarctica which showed four black dots. Officials said that analysis of the dots revealed that they were mountains and there was a strong indication of volcanic activity.

120-in. Solid Test a Success

Aerojet-General on Sept. 19 successfully test-fired a 120-in.-dia. solid motor built for the Air Force Systems Command at its Dade Division South of Miami, Fla. (M/R, Sept. 21, p. 11).

The firm said that the motor met its major objective of proving the design concepts, materials and processes to be used eventually in making a 260-in-.dia., 3-million-lb.-thrust motor.

Harper Gets New NASA Post

Charles W. Harper, authority on simulation and aircraft flight research on the staff at Ames Research Center, has been appointed Director of Aeronautical Research at NASA Headquarters.

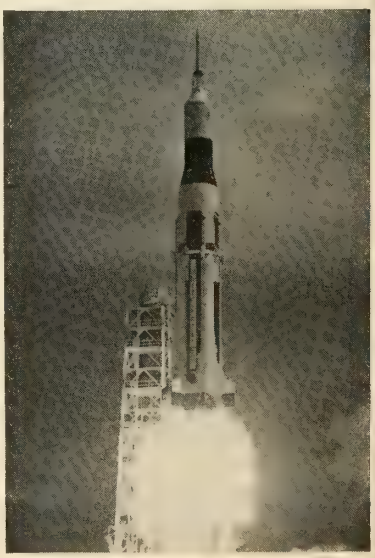
Harper has been chief of the Ames Full-Scale and Systems Research Div. since 1959. In this post, he has been responsible for simulation research in advanced aeronautical and space vehicles. He joined the Ames staff in 1941 as a junior aeronautical engineer and later directed the world's largest (40 x 80-ft.) wind tunnel.

His appointment at headquarters is effective Oct. 11.

Shots of the Week

The boilerplate *Apollo* spacecraft orbited by the *Saturn SA-7* booster on Sept. 18 splashed down in the Indian Ocean Sept. 21, three days, 19 hours and 37 minutes after launch from Cape Kennedy. The craft had completed 59 orbits.

The only troubles encountered during launch countdown were four unscheduled holds. The scheduled hold for loading liquid oxygen into the booster stage was stretched by 5 minutes when a technician on the gantry accidentally turned on an emergency water system filling several electrical lines. Another 29-minute hold occurred when the TPQ-18 radar at Grand Turk Island was knocked out by a faulty relay. Minor holds were called to check out a temperature indicator in the blockhouse and a pressure gage in a LOX tank.



SA-7 lifts off.

Initial orbital parameters were apogee, 140.5 mi., and perigee, 115.53 mi. Nominal parameters were apogee, 135 mi., and perigee, 115 mi.

Bad weather conditions prevented recovery of the eight-camera package (M/R, Sept. 18, p. 54) ejected after separation of the S-I stage from the S-IV stage and prior to ignition of the S-IV engines. Data were received, however, from the telemetry and television systems.

Launch of the next *Saturn* has been slipped into early 1965 because of program delays in *Pegasus* micrometeoroid detection satellite which is to be the payload.

- The Navy successfully launched a *Polaris A-3* missile from the submarine USS Ulysses S. Grant Sept. 21 while it was submerged some 30 mi. off the Florida coast. Firing was the 13th success in 14 submerged shots of the *A-3*.
- An Air Force SAC crew launched an *Atlas* ICBM from Vandenberg AFB, Calif., Sept. 22. Shot was routine training exercise.
- The Air Force on Sept. 23 launched a satellite from Vandenberg AFB, Calif. toward polar orbit aboard an *Atlas-Agena* booster. Purpose of the shot was not disclosed.

MSC Services Award Weighed

NASA is negotiating with a joint venture of Brown and Root Construction Co. and Northrop Corp. for a contract for operational and maintenance support services of laboratories, test facilities and technical service shops at MSC.

A one-year cost-plus-award-fee contract will be negotiated, but options will be provided to extend the contract for two additional years. Cost for the first-year period is approximately $2.5 million with an estimated total cost for the three-year period of approximately $10 million.

The contractor will be responsible for furnishing necessary services, equipment and material to provide technical support to the space environment simulation laboratory, vibration and acoustic test facility, flight acceleration test facility, thermochemical test area and crew systems laboratory at the Houston center. The complex instrumentation and equipment at these facilities are employed for test and check-out of Project *Gemini* and *Apollo* spacecraft and on-board space flight equipment, and for astronaut training.

Technical support services will include preparation of test setups, assisting test operations, preventative maintenance and emergency repair of electronic and mechanical equipment.

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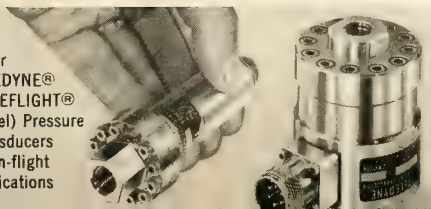


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Goldwater raps disclosure . . .

Anti-Satellite Weapons Tested

by James Trainor

TWO ANTI-SATELLITE systems have been developed and tested by the U.S., President Lyndon B. Johnson revealed in a Sept. 17 speech in Sacramento, Calif. One is based on the *Nike-Zeus* antimissile-missile system and the other on the *Thor-Agena* (M/R, May 11, p. 12).

A family of over-the-horizon radars, which almost doubles the warning time of an ICBM attack on the U.S., has been produced and is being installed, the Chief Executive also revealed.

Disclosure of these two previously classified projects has been interpreted as a Presidential effort to refute Republican charges that new weapons developments have lagged during the last four years of Democratic administration. Reaction to the President's statement was immediate and violent from Republican Presidential nominee Sen. Barry Goldwater, who charged that the President was using classified information in his campaign.

● **Growing list**—Johnson's revelation of the new hardware developments followed his equally dramatic announcements regarding the *Walleye, Shillelagh* and *Redeye,* the A-11, the SR-71 and deployment of the *Polaris A-3,* all of which have taken place in the past six months.

In making his latest hardware announcement, the President said, "We have now developed and tested two systems with the ability to intercept and destroy armed satellites circling the Earth. I can tell you today that these systems are in place. They are operationally ready, and they are on alert to protect this nation and the free world.

"Our only purpose still is peace. But should another nation employ such weapons in space, the United States will be prepared and ready to reply," he concluded.

On the subject of the over-the-horizon radar, the President said: "Today I am also able to tell you—and the entire world—of a major increase in our capacity to detect hostile launches against the free world.

"Previously, our radar capability has

Operational Satellite Killers Need Non-Nucle

DEVELOPMENT of an anti-satellite weapon system—or systems—is far from complete. At present, both the *Nike-Zeus* system and the *Thor* system must depend on nuclear warheads as the kill mechanism for satellite destruction. Also, the U.S. at this time cannot establish the orbital parameters of a potentially hostile satellite on its first or second pass but must wait until he space vehicle is firmly established in orbit.

While the *Nike-Zeus* system, therefore, may well be operational in the sense that it can be used if needed, the Air Force *Thor* and *Thrust-Augmented Thor (TAT)* interception program is just getting under way. Most of the work outlined in MISSILES AND ROCKETS' May 11 story (which, when it appeared, was termed "extremely accurate" by a high-ranking Pentagon official) remains to be done. Foremost among the unfinished tasks is development of a nonnuclear kill mechanism.

Justification of two systems is based on the fact that the *Nike-Zeus* provides a quick-reaction, low-altitude interception capability while the *Thor-Agena* system can intercept at higher altitudes and, because of its Johnston Island location near the equator, can intercept at all orbital inclinations and, if necessary, make minimum-energy orbital plane changes.

Zeus, which is assumed to be located on Kwajalein Island but may well use discarded facilities at Pacific Missile Range, could deliver a warhead of somewhat less than one megaton to an altitude of 100-150 mi., with *Thor-Agena* and *TAT* carrying this to ranges of 400 mi.

At present, Soviet satellite launches are first detected by BMEWS, which as the launch vehicle passes through its dual beam provides information upon which to calculate trajectory information. Radars in Turkey provide essentially the same information. The Shimya, Alaska, radar is able to see the vehicle as it is going into orbit but precise tracking information to establish an orbit is provided by the Air Force tracking network and the Navy's space surveillance "dark fence" across the Southern U.S. Once the orbit is determined, the parameters can be fed into the target intercept computer of the *Zeus* system and the comparable *Thor* ground computer. An intercept is now possible.

However, some military officials stress that by this time the satellite may already have accomplished its mission. Consequently, they say, the U.S. must have a capability to intercept a hostile satellite before it makes its first pass over the U.S. Such a capability does not now exist.

● **Cosmos riddle**—Secretary of Defense McNamara expressed confidence that the U.S. can determine the intent of a satellite launched by the Soviet Union, but another Administration official who should be at least as knowledgeable professes ignorance of the purpose behind some of the *Cosmos* launches.

This program is divided into four phases, three of which are clearly scientific or military in purpose. However, the fourth involves heavy (15,000 lb.) satel-

been limited to detection of objects within the line of sight. But now we have produced, and we are installing, our first facilities for 'over-the-horizon' radar. This radar will literally look around the curve of the Earth, alerting us to aircraft, and especially missiles, within seconds after they are launched."

● **McNamara amplification**—The following day, Secretary of Defense Robert S. McNamara added a few, closely-hedged details about the two new developments. The *Nike-Zeus* anti-satellite weapon, operated by the Army, was operational Aug. 1, 1963—some 14 months after go-ahead in May, 1962. The *Thor*-based system, also operational in little more than a year after go-ahead, was declared ready on May 29, 1964.

Both systems, the Secretary said, are under the operational control of the Continental Air Defense Command. Some $80 million has been invested in the two systems, McNamara said, not including funds expended in the A-ICBM system or the Space Detection and Tracking System (*SPADATS*).

On the over-the-horizon radar, McNamara estimated that more than $50 million has been spent on these systems in the last two or three years. These are a "family of radars," the Secretary stressed, and not just a single system. When they are installed, they will almost double the warning time against attack—from approximately 15 minutes to a little less than 30 minutes.

● **Details**—McNamara also made these points:

—Both anti-satellite systems use data from "our global space detection and tracking networks of the Air Force and the networks of the Navy."

—The two systems have been "thoroughly tested" and have intercepted U.S. satellites in space, "passing so close to the satellites as to be within the destruction radius of their warheads."

—Characteristics of the two systems differ sufficiently to warrant development of both. Early study hadn't shown that the Air Force had a capability with the *Thor* to develop such a system. The Air Force later not only proved the *Thor* capability could be developed but also proved that it would provide additional capabilities to supplement the *Nike-Zeus* system.

—Neither system has a loiter capability. The interceptor "has to be there when the satellite is there. This is one of the very important characteristics of the system. It is both a requirement and a capability."

—Work on over-the-horizon radars has been going on since 1949 in the U.S. and during the 1950's by the British. But the "big leap forward" came from work done within the last two or three years, starting with some very important tests in 1962.

—The Soviet Union doesn't have the over-the-horizon technique, but will probably develop it in a few years. "They may do it five or seven or eight years later." Also, the Secretary believed that "we would know if they had advanced as far as we have in this field."

Development of the over-the-horizon capability increases the survivability of U.S. bomber forces and may permit certain aircraft warning systems to be phased out. In particular, McNamara singled out DEW line extensions—picket ships and various other types of forward radar warning systems—as possible facilities that can be replaced by the new radar "after it becomes operational and we have determined its whole capability."

The Ballistic Missile Early Warning System (BMEWS) complements the new family of radars, the Secretary pointed out. "We don't anticipate that this over-the-horizon radar will replace BMEWS, certainly not at any time in the foreseeable future, say five or eight years." ■

Destruct Device

lites launched on inclinations of 65 degrees from Tyurtam and recovered after varying periods in orbit.

The Soviets seem to be concentrating, the Administration official says, on precision recovery—but not in any way that could be related to manned spaceflight. The purpose of these satellites is not known, he says. Its bearing on the U.S. decision to develop an anti-satellite capability as an insurance policy is even less clear.

● **Radar breakthrough**—Key to the "big leap forward" in over-the-horizon radars in the past two or three years is a new high-powered radar tube. Developed within the Advanced Research Projects Agency's Defender program, the S-Band tube provides the breakthrough required in output power within a frequency band which can be reflected by the ionosphere.

Applicable to forward-scatter systems—a major component in the "family" of over-the-horizon radar—the tube provides frequencies of 2,000-5,000 megacycles with wavelengths of 15 to 5.5 centimeters. This energy is directed at the "F" layer of the ionosphere, within which it is bent (or reflected) back to Earth. The "F" layer used in the new radar is located at an altitude of 100 mi. above the Earth, and, although this ionized path varies considerably from day to night, the electron densities are sufficient to refract the signals back to Earth.

Attenuation of the radiated energy is relatively small in the ionosphere because of the very low density of neutral particles and the infrequency of collisions between them and electrons. However, upon "reflection" back to the Earth there is considerable attenuation by the ground. Therefore, Defense experts stress that the maximum number of ionospheric reflections would be three.

Two possibilities for forward-scatter systems are being developed. The first involves a conventional radar approach in which the receiver is co-located with the transmitter and "listens" for the radar echo. The key to this approach is an extremely sensitive magnetic drum —developed in the Navy's Madre program—to discriminate the returning signal from the unpatterned noise.

In the second approach, the receiver is located "downstream" from the transmitter and picks up the signal after its second or third bounce from the ionosphere. For example, a transmitter located in the North Central part of the U.S. could bounce its signal off the ionosphere, using one or two hops, so that it is focused in the Soviet Union. Ground reflection would then be picked up on the next return from the ionosphere at an installation in the Indian Ocean—such as the Seychelles Island site or perhaps a picket ship.

Basically, the forward-scatter holds the most promise for both missile and aircraft launching, since the pulse system would not depend on induced changes in the ionosphere produced by missile exhausts. Back-scatter, however, is under development as an important component of the over-the-horizon radar family. First suggested in the late 1950's as a means of detecting nuclear explosions, back-scatter techniques were developed under Project Teepee. They can now detect missile and missile exhaust influences on the ionosphere.

In addition to the $50 million which Secretary McNamara estimated would be necessary in future years for installation of the systems, work is still being conducted on over-the-horizon systems. Primary emphasis now is on extreme precision and accuracy. ■

In Chicago speech . . .

McNamara Details Nuclear Yields

Says single army division in Europe has enough nuclear punch to destroy populations of 50 largest U.S. cities

THE SMALLEST nuclear weapon deployed in Europe today has a force "tens of times greater than the 1,000 lb. conventional bomb of the last world war," Secretary of Defense Robert S. McNamara told the Executives' Club of Chicago in a speech read for him by Army Secretary Stephen Ailes.

Noting that the word "small" in relation to any nuclear weapon "can be dangerously misleading," McNamara's speech pointed out that "the average tactical nuclear bomb in Western Europe today has a power five times greater than the atomic bomb dropped on Hiroshima."

Excluding bombs, the average tactical nuclear weapon in Western Europe has a yield at least equal to the Hiroshima bomb. The nuclear firepower available to a single U.S. division in Europe, the Secretary said, "is sufficient to destroy the combined populations of the 50 largest cities in the United States."

● **Rebutting Goldwater**—McNamara's speech had been billed in advance as a "definitive" statement on tactical nuclear weapons and an answer to assertions by Sen. Barry Goldwater that field commanders, and particularly the NATO commander, should have authority to employ tactical nuclear weapons. The Secretary had planned to deliver the speech himself, but the Sept. 18 Tonkin Gulf incident prevented his doing so.

The "very serious problem of the nuclear radiation which accompanies all of our nuclear weapons, large or small, deserves special emphasis," McNamara said. "In fact, the smallest nuclear weapons kill primarily not by blast, but by radiation.

"I believe it would be hazardous, in the extreme, to erase or ignore the line separating nuclear weapons of any kind from the conventional weapons of past wars. There are some who do not concern themselves with this distinction," the Secretary said in a thinly veiled thrust at the Republican nominee.

"But in Europe, where tactical nuclear weapons would most probably be used, our allies are concerned. I am concerned. The President is concerned. And I think the American people are very much concerned."

● **The inventory**—Available to the Army for division use, although some of these weapons are not organic but support division operations, are a wide variety of nuclear weapons. Included are the 8-in. howitzer, the *Honest John*, the *Davy Crockett* (approved as an augmentation only of the division equipment), *Sergeant* and *Pershing*. *Little John*, which is only organic to airborne divisions, also has nuclear capability.

Although the Army announced earlier this year that a nuclear round for the 155-mm howitzer had been approved, Army officials now stress that the round is not being stocked and is not available to troops in the field. ■

Gates Criticizes McNamara Views

FORMER Secretary of Defense Thomas S. Gates has characterized Defense Secretary Robert S. McNamara's presentation to the Democratic Platform Committee as "not a true representation of the Department of Defense of which you assumed charge in 1961."

In a reply to a telegram from McNamara, Gates went on to say that "if the allegations you made, at complete variance not only with the content of your dispatch to me but also with a number of statements you had earlier put on the public record, were inserted in your presentation to serve a political purpose, then Aug. 17 was an unfortunate day for the process of government in this nation."

Gates reminded McNamara that he had to defend the policies and programs of the Eisenhower Administration in 1960 "when I was obliged to combat and clarify publicly the phoney issue of a so-called 'missile gap.' "

In a telegram to Gates after Treasury Secretary Douglas Dillon had informed him that Gates was concerned over the platform committee statement, McNamara said that "for three and one-half years I have tried to prevent defense policies and programs from being discussed in a partisan context."

He then quoted a series of allegations by Sen. Barry Goldwater that American strength was deteriorating, saying that efforts to keep politics out of defense have "become increasingly difficult over the past several weeks as Senator Goldwater has persistently made defense a partisan political issue."

"I need hardly tell you how much I appreciate your contributions to the national security and the importance of programs and policies you instituted as Secretary of Defense," McNamara cabled Gates.

Before the Democratic forum, McNamara had charged that: the Defense Department in 1961 had operated with but a single strategy, and also that military strategy was a stepchild of a predetermined budget; planning was without coordination between the services; weapons inventory was completely lacking in certain major elements required for combat readiness and the nation's strategic force was vulnerable to surprise attack.

"I am totally unable to reconcile what you told the platform committee with the tone and content of your dispatch to me," Gates told McNamara in a letter replying to the Secretary's telegram. "If the conditions actually had been as you have described them, then I could not conscientiously have remained in office —nor would I have been allowed to. . . ."

McNamara released the correspondence at Gates' request.

For first half of 1966 . . .

Geodetic Balloon Satellite Readied

by Hal Taylor

NASA HAS ANNOUNCED it will use three different satellites in a five-flight project to map the Earth's surface and its gravitational field.

The first step in the new program will be taken next month with the launch of a *Beacon Explorer* spacecraft.

The two other spacecraft in the series will be the heavily instrumented *GEOS* and a passive geodetic satellite developed by the Langley Research Center.

The program is an outgrowth of NASA's assumption of responsibility for DOD's *ANNA* satellite program in Fiscal Year 1965. It is based on the recommendations of the Geodetic Satellite Policy Board composed of representatives of NASA, DOD and the Dept. of Commerce.

Two types of geodesy—gravimetric and geometric—will be employed to gather information on the Earth's size, shape, mass and variation in gravity which is not obtainable by other means.

Gravimetric geodesy is concerned with measuring variations in the Earth's gravitational field. Geometric geodesy employs principles of geometry to map the Earth's surface in a three-dimensional reference system. The space agency plans to pay particular attention to relating specific position on island continetns to each other.

● **BE-B mission**—The *Beacon Explorer* (*BE-B*) satellite will be launched by a four-stage *Scout* booster from the Pacific Missile Range. Its main objective will be to determine the electron count of cross-sections of the ionosphere between it and Earth.

Two other experiments are also highly important. One will evaluate the use of laser techniques in obtaining accurate orbital and geodetic information. The other is a Doppler transmitter to measure the effect of irregularities in the Earth's gravitational field.

The laser experiment will utilize 360 one-inch reflectors pointed so that a laser beam can be reflected back to its ground source. The time it takes for the light beam to make the round trip will determine the spacecraft's position with greater accuracy than the currently used radio means. The space agency says problems in aiming the ground-based laser source make chances of initial success marginal.

BE-B was designed and built for NASA by the Applied Physics Laboratory of Johns Hopkins University. It will be launched into a polar near-circular orbit of about 620 mi. If it is successful, it will be followed by *BE-C*, which will continue the radio beacon experiment for ionosphere studies and the laser test. It will also be placed in a 620-mi. circular orbit but it will be launched from Wallops Island.

● **GEOS plans**—The 350-lb. *GEOS* satellite will also be developed for the space agency by the Laboratory. Far more heavily instrumented than the 120-lb. *Beacon Explorers, GEOS* satellites will carry flashing lights, a variety of electronic beacons, optical reflectors, and when space permits, radar reflectors.

The launch of *GEOS A* by a *Thrust-Augmented Delta* is planned for the third quarter of 1965. It will be launched from an inclination of 59 degrees into an elliptical orbit ranging from 700 to 900 mi. in altitude. A successful *GEOS A* flight will be followed by a second flight in the second or third quarter of 1966.

Launch date of the passive balloon-type geodetic satellite is set for the first half of 1966. It will be placed in an almost circular polar orbit at 2,300 mi.

It will be tracked by several systems including one with a network of 36 camera sites. The stations, 2,500 to 2,800 mi. apart, will use triangulation to provide data required to establish precisely all points on Earth in a three-dimensional coordinate system.

As a result, it is expected that any point on Earth can be located, as measured from the center of the mass, to within 32 ft. of its true position. It will also be able to measure the distance between two points on Earth 2,000 mi. apart with the same accuracy.

The Smithsonian Astrophysical Observatory, under contract with NASA, will obtain optical data from both the flashing light and the passive balloon experiments, using its worldwide system of Baker-Nunn cameras.

The Dept. of Defense's worldwide support program will integrate use of existing Army *SECOR* ground stations, Navy Doppler tracking stations and Air Force geodetic stellar camera systems that will observe the flashing lights. ■

Texas Gets 84-in. Scope

NASA and the University of Texas have signed a contract calling for development of the world's fifth largest optical telescope, which will be used for lunar and planetary observation.

The space agency will provide $2.1 million to build the 84-in. reflecting telescope at the University's McDonald Observatory (M/R, Sept. 21, p. 17).

The University will fund a $759,000 Observatory building as well as provide $1.2 million for associated shop buildings. The facility is scheduled to be operational in 1968.

The contract was signed Sept. 22. Initial-year funds will be $700,000.

NASA said the telescope will be devoted mainly, but not exclusively, to lunar and planetary studies correlated with past and future exploratory space flights.

One plan calls for telescope observations of the *Ranger VII's* impact area so that the observations can be related to the photos the spacecraft relayed back to Earth. Another plan calls for observation of Mars so that information can be gathered on its atmosphere. This data would be incorporated into mission and experiment planning for future spacecraft flights to that planet.

The McDonald Observatory is located at Fort Davis in West Texas. The telescope's size is topped only by the 200-in. at Mt. Palomar, the 120-in. at Lick and the 100-in. Mt. Wilson telescope, all in California, and the 100-in. telescope at Russia's Crimean Astrophysical Observatory.

House Panel To Begin Scrutiny of Government-Funded Basic Research

R&D Subcommittee Chairman Daddario seeks expert advice on evaluation of programs; group has published R&D geographical report

by Heather M. David

FIRST HARD LOOK at the spectrum of government-funded basic research has been initiated by the House Science and Astronautics Committee. The committee will receive its first report by the end of the year.

The committee, usually referred to as the House "space" committee, just this year began taking the "science" in its name seriously. Latest move of the Science, Research and Development Subcommittee headed by Rep. Emilio Q. Daddario (D-Conn.) has been to make a permanent affiliation with the National Academy of Sciences, on which it will call for continuing advice.

An *ad hoc* committee has just been appointed by the NAS to aid the subcommittee in its review of basic research. This group, headed by Dr. George B. Kistiakowsky, former science adviser to President Eisenhower, will report by the end of the year its answers to these questions:

—What level of Federal support is needed to maintain U.S. leadership through basic research in science and technology and their economic, cultural and military applications?

—What judgment can be reached on the balance of Federal support to the various fields of scientific endeaver and what adjustments should be made under existing, decreased or increased overall support?

Perhaps in deference to the traditionally individualistic viewpoints of scientists, the committee said it will ask that the scientific committee make its report in individually signed statements, rather than try to arrive at a consensus. A tally will be made of the responses to each question, however.

This will mark the first Congressional use of the National Academy of Sciences, whose charter, signed by President Lincoln, requires it to be available to advise all branches of the Federal Government.

• **New data released**—The subcommittee has just released published hearings conducted on the geographical distribution of research and development funds on the question of indirect costs on Federal grants.

Data appendiced on the distribution of R&D give some new figures on the total picture. In geographical areas, the information shows that profit-making organizations in the Pacific Coast states (Wash., Ore., Calif., Alaska, Hawaii) lead with $4.1 billion awarded in that area, nearly half of the total.

Next is the Middle Atlantic (N.Y., N.J., Pa.) with $1.544 billion, followed

Distribution of All Government Research and Development Funds, FY 1963

(In thousands of dollars)

STATE	DOD	NASA	AEC	TOTAL*
Alabama	27,829	102,483	171	137,314
Alaska	2,241	1,273	61	5,554
Arizona	127,119	6,102	488	139,460
Arkansas	10	14,201	279	17,133
California	2,261,903	1,235,960	230,467	3,807,821
Colorado	203,506	5,748	1,300	221,581
Connecticut	70,965	7,775	31,959	122,985
Delaware	23,298	250	92	24,490
Florida	129,693	104,738	2,132	247,808
Georgia	2,199	4,990	691	15,341
Hawaii	1,380	118	152	4,126
Idaho	575	198	25,889	27,621
Illinois	84,024	13,126	55,412	191,143
Indiana	31,722	2,492	4,256	49,681
Iowa	2,935	2,501	6,274	18,537
Kansas	13,547	916	497	20,380
Kentucky	609	81	156	5,647
Louisiana	2,003	170,123	152	181,964
Maine	205	195	238	2,967
Maryland	241,305	52,321	6,286	324,561
Massachusetts	328,771	42,480	13,719	451,918
Michigan	96,858	8,353	3,800	133,518
Minnesota	41,608	8,317	1,780	68,853
Mississippi	558	81	31	4,008
Missouri	16,377	201,494	238	232,842
Montana	3,114	70	27	4,799
Nebraska	332	3	110	3,665
Nevada	1,124	647	121,976	124,474
New Hampshire	10,995	571	93	14,199
New Jersey	202,910	57,201	14,206	287,758
New Mexico	28,136	2,797	193,442	226,207
New York	631,810	79,777	98,710	917,419
North Carolina	6,426	710	1,057	21,972
North Dakota	1,161	0	19	2,284
Ohio	118,849	27,561	16,292	185,735
Oklahoma	6,237	1,025	417	13,058
Oregon	2,014	445	543	12,630
Pennsylvania	162,061	47,824	94,593	348,986
Rhode Island	5,550	252	508	9,711
South Carolina	356	75	12,345	14,689
South Dakota	10,299	401	346	12,216
Tennessee	41,988	1,794	71,796	133,623
Texas	168,241	136,415	1,864	330,870
Utah	113,928	320	846	120,019
Vermont	2,074	48	90	4,904
Virginia	36,632	26,664	2,090	73,104
Washington	277,544	1,983	29,480	321,273
West Virginia	1,118	168	50	5,434
Wisconsin	63,772	12,019	4,282	95,024
Wyoming	1,470	0	0	2,342
District of Columbia	37,945	64,123	596	120,494

* Total includes Health, Education, and Welfare, National Science Foundation, Agriculture, Interior and Commerce.

by the Mountain States (Mont., Ida., Wyo., Colo., N. Mex., Ariz., Utah, Nev.) at $866 million.

Then come the South Atlantic (Del., Md., D.C., Va., W. Va., N.C., S.C., Ga., Fla.) at $847 million, and the East North Central (Ohio, Ind., Ill., Mich., Wis.,) with $655 million. Last are New England, (Maine, N.H., Vt., Mass., R.I., Conn.) $606 million; West South Central (Ark., La., Okla., Tex.) $543 million; West North Central (Minn., Iowa., Mo., N.D., S.D., Neb., Kan.) $358 million; and East South Central (Ky., Tenn., Ala., Miss.) $280 million.

The committee report is due within weeks. The group also is expected to draft legislation on the setting of allowances for indirect costs on government contracts incurred in research projects. Considerable opposition has been voiced toward the 20% -of-contract allowance that has been proposed. ■



GT-2 Arrives at Cape

THE SECOND Gemini capsule has arrived at Cape Kennedy from McDonnell Aircraft in St. Louis and sent to the Merritt Island Pyrotechnics Building for uncrating and preliminary checkout. The 7,000-lb. spacecraft will next proceed to the Fluid Test Complex where its hydrogen peroxide thrusters will be test-fired. Mating to the Titan II will follow.

While in the Senate . . .

Committee Will Study Use of ADP

THE POWERFUL Senate Committee on Government Operations headed by Sen. John McClellan (D-Ark.) will consider legislation early next session on the use of automatic data processing equipment in government work, a subject which has polarized missile/space contractors and the General Accounting Office.

The full-scale review will bring to a head the controversies over the use of ADP equipment in government contracts that have raged for many years. Points causing the most dissension involve whether one government agency such as the General Services Administration should administer the use of all ADP equipment used in government contracts, and whether the equipment should be bought instead of leased.

A long list of defense and space contractors, together with the Defense Department, have been the subject of GAO reports that allege waste of millions of dollars in the use of electronic data processing equipment.

McClellan said his committee will take up a number of bills on the subject, including one already passed by the House. This bill, which the Senate committee has also considered revising, authorizes the administrator of General Services to coordinate and otherwise provide for a government-wide policy of buying equipment. Sen. Paul Douglas, (D-Ill.) said that he will introduce a companion bill to the House bill.

● **Budget cuts triggered**—The costs of leasing ADP equipment have resulted in budget slashes by Senate committees on both defense and space bills, in an effort to bring about action in this area.

President Johnson has also indicated that he supports legislation. He is due to receive a study conducted by the Bureau of the Budget in a few weeks making its recommendations.

There are about 1,800 computers in use in the government, and plans are under way to obtain hundreds more. Costs are estimated to have risen from $251 million in 1959 to about $1,053 million in FY 1965. Legislation will obviously have great effect upon computer companies.

The bill passed by the House (HR 5171) is opposed to one degree or another by almost all missile/space companies and government agencies except the General Accounting Office and the General Services Administration.

● **Industry comments**—North American Aviation President J. L. Atwood voiced the feeling of many missile/space companies questioned by the committee, when he said the concern of NAA was about the clause that provides for GSA control of equipment purchased, leased and maintained "at the expense of Federal agencies." Under the present system, most computer work is leased by the contractor, with costs included in the government contract.

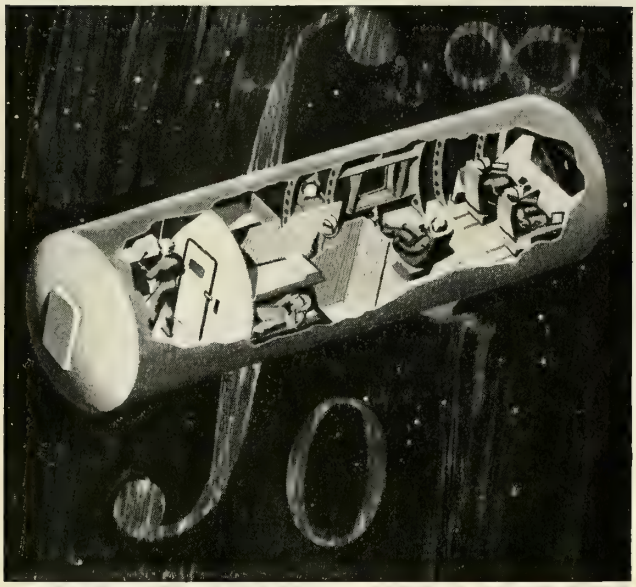
Atwood, along with Aerojet-General President W. E. Zisch and Martin Vice President Howard W. Merrill, indicated that their opposition was partly based on the extra costs that might result from delays in obtaining computers when going through a central agency. Zisch pointed out that the contractor could be placed in the position of having to justify its requirements to the GSA while defending its performance to DOD, NASA and the other Federal agencies.

General Dynamics President Roger Lewis asked that if the bill be enacted, organizations "other than Government agencies," be specifically excluded. "We believe that effective utilization of ADP equipment by contractors can be achieved through good contract administration rather than through legislation of this nature," he said .

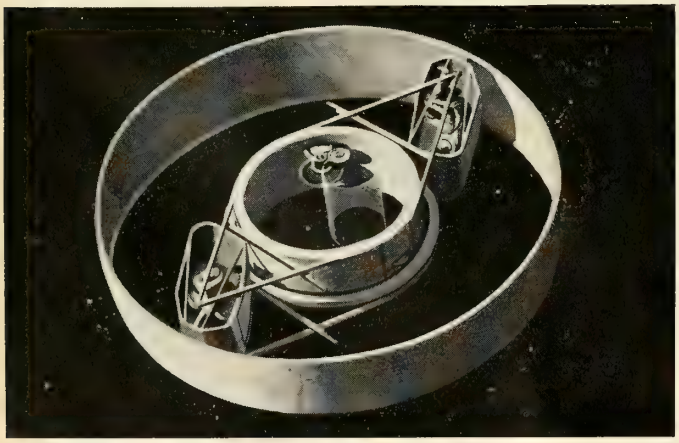
Electronic Industries Association General Counsel John B. Oliverson also came out strongly against the bill, saying that in addition to raising contract costs in defense and space programs, it would impede the development and advancement of computer technology.

Hearings will be held by the committee early next year, Chairman McClellan said. ■

For continued progress in the conquest of space, depend on DOUGLAS



A MATHEMATICAL SPACE SYSTEM has been built by Douglas to save thousands of hours in building a real one. Computers analyze all the requirements for a complete life-support and environmental system, figure out how to satisfy them, and even indicate design details of equipment that will do the best job.



AN EXERCISE MACHINE FOR SPACEMEN, this small centrifuge will restore earth vigor to astronauts weakened by the lack of gravity in an orbiting space laboratory. Designed and being tested by Douglas, it will be used periodically by members of a space crew.



DOUGLAS ADDS MORE BOOST TO DELTA, world's most reliable space booster, by adding solid-fuel rockets to its first stage. The standard version, still in use by the U.S. National Aeronautics and Space Administration (NASA), has the remarkable record of performing perfectly in 22 consecutive space research missions.

DOUGLAS

MISSILE & SPACE SYSTEMS DIVISION

Technical Countdown

ELECTRONICS

Low-power Data Processor Ordered by Goddard

An 8-oz., 13-cu.-in. data processor requiring from 0.28 to 0.37-watt total power will be evaluated by NASA for possible use in *OGO-E*, an *Orbiting Geophysical Observatory* with eccentric orbit. Being developed by General Instrument Corp. for the agency under a $94,377 nine-month contract, the sub-system is scheduled for delivery to Goddard Space Flight Center next February. The unit, said GIC, will employ some 150 microcircuits including 97 flip flops. The design will permit a data input rate of 10^6 bits/sec. and an output of 64,000 bits/sec. The eight-channel processor is comprised of 10 modules, including seven binary counter registers. Each of the registers employs nine ceramic-mounted, silicon-planar, complementary flip flops.

AF Seeks Sensitive Laser Receiver

An ultra-sensitive laser receiver will be studied and, possibly built, under a $90,000 contract received by Sylvania's Mountain View, Calif., facility. The R&D effort includes a study of laser communications techniques and a demonstration of a prototype optical receiver by Spring, 1965. Methods, said Sylvania, will be explored for the detection and amplification of very weak AM and FM optical signals. Techniques for both laser communications and radar will be investigated.

New Pulse Compression System Reported

A new method for performing radar system pulse compression-expansion functions provides compression ratios up to 1,000:1 and bandwidths up to 25 mc, claim developers at Andersen Laboratories, Inc. Called Delecon (for Delay, Extend and Contract), the system is described as small (roughly 2 cu. ft.), inherently stable and reliable, and low in cost. Capable of replacing several racks of conventional equipment required to perform the range functions, Andersen Labs asserts that its concept makes existing systems obsolete. Delecon design is based on the use of acoustic transmission in fused quartz, the firm said.

CSC To Build Saturn V Test ADP

Two SDS-930 digital computers, built by Scientific Data Systems, Inc., will be used simultaneously to process *Saturn-V* static-firing test data at NASA's Mississippi Test Operation. The general purpose computers will be combined as a part of the Data Handling System to be designed, built and installed at the facility by Consolidated Systems Corp. under a recently announced $1.6-million contract from AETRON Div. of Aerojet-General Corp. AETRON is prime contractor to NASA for the entire *Saturn-V Data* Handling Center. The system is presently scheduled for installation early next year.

TV Boosts Microscope Magnification

A ten-fold magnification increase has been obtained by RCA by applying television techniques to an electron microscope. Using a 3-in. orthicon and image intensification, magnification was raised to $2x10^6$ times. Specimens are intensified and displayed on a standard TV monitor. Through the use of the RCA approach, some materials normally destroyed or altered by the electron beam may now be re-examined using a somewhat weaker beam. A secondary advantage of the use of TV is the capability to produce a video tape of occurrences under study, thus recording transient phenomena previously lost. Still photos can be made at will from the video tape presentations.

MATERIALS

Macrosonic Tools and Techniques Developed

Microsonic irradiation can reduce the forces required to plastically deform metal by up to 100%, claims the U.S. Naval Ordnance Test Station, China Lake. The use of ultrasonic high intensity energy, according to Dr. Berwin Langenecker, permits efficient forming if the acoustical energy is properly directed toward the deformation zone. NOTS has already developed ultrasonic tools to implement metal ironing, curling, deep drawing, rolling and cropping. So far, said Langenecker, development of suitable macrosonic transducers and achievement of good energy coupling to the deformation zone remain the biggest obstacles to applying these techniques to large-scale industrial uses.

Ultra-high Vacuum Zone Refiner Available

Zone purification of materials and single-crystal growth can be achieved at pressures down to 10^{-9} torr and at temperatures above 4,000°C with a new electron-beam refiner, according to MRC Manufacturing Corp. A 10-in. vacuum system provides 4,200-liter/sec. pumping speed. Through use of the very high vacuum, MRC stated, single-pass refining will produce purities available previously only through multiple-run zone refining. The new unit, Model EBZ-94, equals or improves purity at both reduced time and cost, developers claim. The system employs a hydraulically moveable stainless steel bell jar housing the electron-beam assembly and scanning devices. All operations are controlled externally.

BIOTECHNOLOGY

Lockheed Maintains Unique Algae Farm

Lockheed-California has disclosed that it has maintained an algae farm for three years without addition of fresh strains and with no loss of vitality in the culture. During this time, Lockheed engineers also developed a unique cylindrical tube system in which the algae is grown in strips circumferentially within the tubes. The culture is "swirled" around inside the tubes, in a "flowing film" pattern to expose all cells to illumination from the exterior.

Martin Probes Extraterrestrial Life Detection

A new method to detect extraterrestrial life is being studied at the Martin Co.'s Research Institute for Advanced Studies (RIAS) under a one-year NASA contract just awarded. The principle premise is that any organisms that might exist would use water as a solvent for the chemical reactions in their metabolism. Enzymes within these extraterrestrial organisms would then trigger an exchange in water itself and oxygen-containing salts dissolved in it. The researchers feel that this method will detect even forms of life that are not based on the carbon cycle.

Valveless Control Rockets Developed

Subliming propellant is activated by radiant energy; can be pulsed for 200,000 hours for use in attitude control, spin maneuvers

by John F. Judge

A PULSE-OPERATED solid rocket with no moving parts is being developed by Rocket Research Corp., for control of satellites and space vehicles.

Designated the Valveless Rocket, the device uses a special subliming solid propellant with a radiant energy source. There are no pressure regulators, propellant tank bladders, pressurization systems or valves in the design.

A typical Valveless Rocket consists of a charge of subliming solid propellant in a propellant tank. The charge is in open communication with an exhaust nozzle.

Under normal operating conditions, the subliming solid grain releases very little vapor. The propellant responds to radiant energy. When this energy is applied, sublimation occurs and the resulting vapor passes through the nozzle, producing thrust. Cutting off the radiant energy source halts sublimation and eliminates thrust. Pulsing is achieved by on/off sequencing of the radiant energy source.

The Valveless Rocket is an outgrowth of the Seattle, Wash., firm's research on subliming solid control rockets. The key to operation is the control of sublimation by radiant energy. Since there is no ignition nor combustion, the rocket may be pulsed indefinitely.

Overall reliability is a function of the reliability of the radiant energy source and the stability of the propellant. Many different types of radiant energy may be used; the choice depends on the desired operating characteristics.

Typical radiant energy sources used have been types that can be pulsed repeatedly with lifetimes from 10,000 to 200,000 hours. They are designed to withstand the launch and space environment. The propellant itself is stable and has an indefinite storage life.

● **Performance proven**—Specific impulse between 60 and 80 seconds is generally achieved with the Valveless Rocket—depending on the thrust level and operating conditions.

One unit recently tested by Rocket Research has a design total impulse level of 500 lbs.-sec. It measures 4 in. across and about 15 in. high. Michel E. Maes, program manager, says the emphasis has been on low thrust levels because an analysis of potential applications showed requirements in the 10^{-5} to 10^{-3} lb.-thrust range for very long missions.

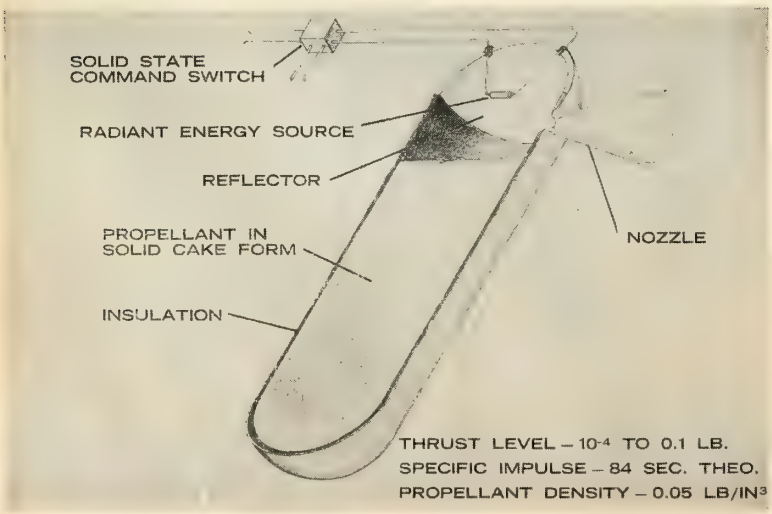
The current thrust levels possible are from 10^{-4} to 0.1 lb. with a theoretical Isp of 84 sec. The propellant density is 0.05 lb./in.^{3}.

In addition to the startling reliability advantages, lack of both moving parts and high operating pressure is significant in total system-weight.

Maes and his group chose the propellant formulation for its subliming properties and its molecular weight. The propellant has a molecular weight sufficiently low to yield better performance than nitrogen gas, according to Maes.

The propellant tank weighs no more than 0.1 that of the total propellant weight because of the low operating pressure. The radiant energy source and nozzle assembly are also lightweight. Compared with a nitrogen gas reaction system, Maes says, the Valveless Rocket system is lower in weight by a factor of two.

The electrical power necessary for operation is on the order of 10 to 15 watts per millipound of thrust, and power is required only when the rocket



OPERATING SCHEMATIC of Rocket Research Corp. valveless rocket shows relative simplicity of achieving pulsed cycling by turning the radiant energy source on and off. Numerous types of radiant energy sources are available for use with the special subliming propellant.

is operating. For certain power-limited applications where the operating duty cycle of the Valveless Rocket is low, small batteries can maintain the power during the operating periods. A low power recharge can be applied to the batteries during the off periods.

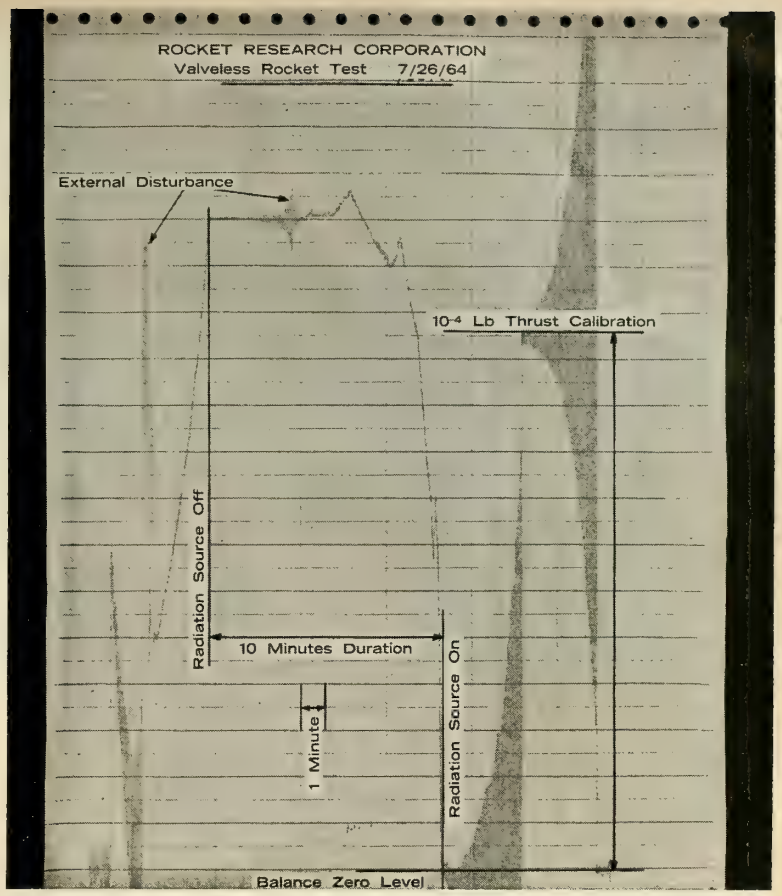
Maes and his staff are continuing efforts to reduce the operating power of the engine.

● **Part of a family**—There are several other Valveless Rocket configurations besides the typical unit described. Rocket Research has designs for double thrustor units—and even the potential application of lasers as radiant energy sources. Another configuration fits relatively high-thrust applications. Here the radiant energy source is a single longitudinal filament positioned through an end-to-end core in the propellant grain.

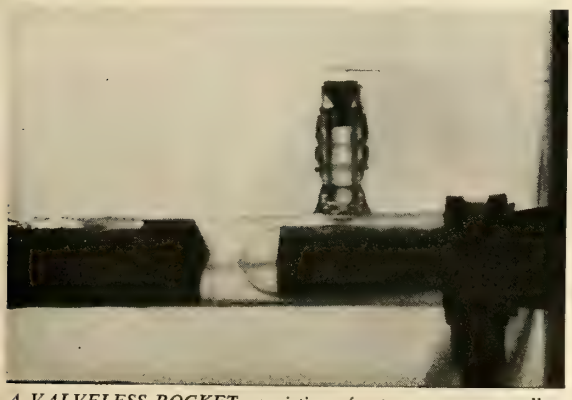
Still another configuration could use the Sun as the radiant energy source. A possible application would be the use of a totally passive attitude-control system for solar-oriented vehicles. Misalignment of the vehicle with respect to the sunline would result on impingement of sunlight onto the subliming solid surface. The thrust produced could drive the vehicle back to its deadband position.

Maes says all existing control rocket systems have a valve of some sort, which has always been a major source of unreliability on long-life missions. Since the Valveless Rocket has as its primary characteristic the absence of moving parts, the applications are mainly those requiring thousands or even millions of on-off operating cycles.

The firm has analyzed a number of potential missions for the rocket. The most promising are characterized by long-life and low-thrust-level requirements. These include orbital station-keeping, vehicle spin-up and re-spin, interplanetary attitude control and solar orientation. ■



TYPICAL THRUST TRACES produced by valveless rockets on the pendulum balance. Balance of the restoring force can be adjusted to very low levels. Sensitivity is high and measurements are possible at 10^{-5}-lb. thrust levels with high recorder deflection and an accuracy better than 3%. Trace shown is a 10-minute run with the impressed force calibration appearing on the right side of the trace. The two external disturbances noted were caused by the movement of large trucks in the close vicinity of the laboratory.





A VALVELESS ROCKET consisting of a transparent propellant tank, a propellant charge, radiant energy source and nozzle in open communication with the propellant is shown in both conditions. LEFT: With the radiant energy off, the target (upper right) protrudes horizontally over the nozzle opening indicating that no exhaust is present. RIGHT: The target is deflected upward as the radiant energy source is turned on, generating exhaust vapor.

Navy Propellant Mixer Technique Employs Gas Turbulence in Porous Tube

New method reduces explosion hazard while offering economy, efficiency; production-size versions said practical; offers easy quality control and accommodates variety of ingredients

INDIAN HEAD, MD.—An economical and highly efficient composite solid-propellant processing method developed at the Naval Propellant Plant may be the answer to the high-volume production requirements posed by large solid boosters.

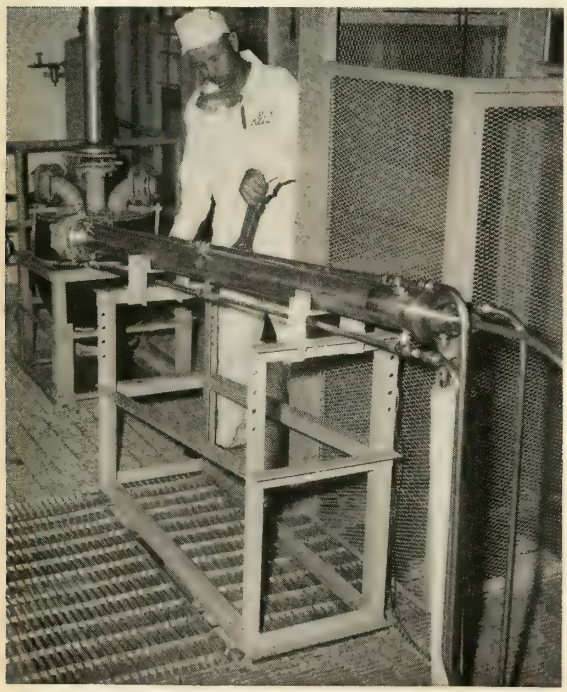
Engineered gas turbulence in a porous tube provides the mixing function in the NPP Pneumatic Mix Process. The crucial mixing innovation is the creation of Albert J. Colli, Supervisory Chemical Engineer and co-holder of the patent on the entire process.

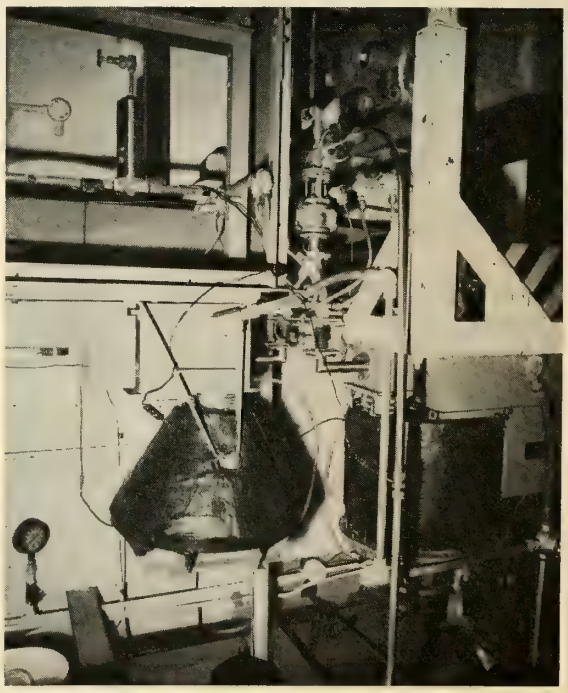
Extrapolation of current pilot plant operations indicates that a 25,000 lbs./hr. facility using the process can be built for less than $1 million. This is an order of magnitude less than comparable costs for blade mixing installations.

Because so little propellant is in the actual mixer at any given time, the explosion hazard is greatly minimized.

Colli's innovation is the use of a sintered-steel porous tube as the mixing station. Liquid and solid ingredients are fed into the tube while air or a suitable gas is injected at pressure into a jacket surrounding the mixing tube. The injected gas pressure is high enough to cause turbulent mixing in the tube while keeping the propellant away from the sintered walls.

● **Automatic mixing**—Uneven radial distributions between the two ingredient

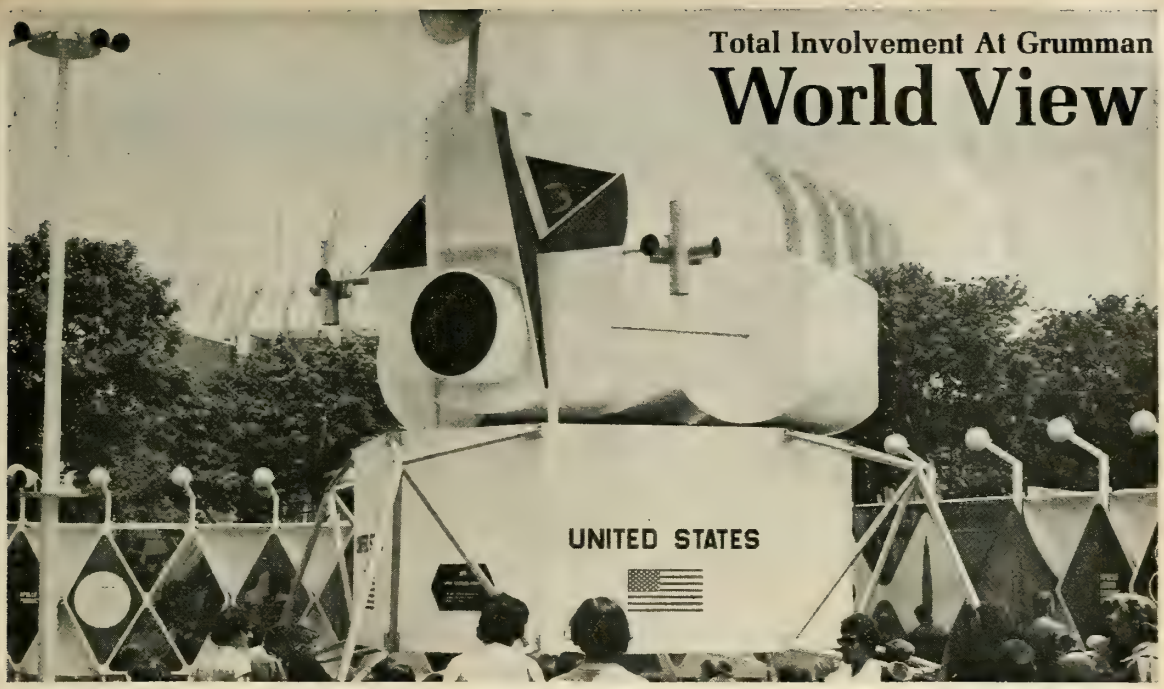




LEFT: Mixing station in the pneumatic process is housed in jacket being checked by propellant operator at Naval Propellant Plant's pilot facility. RIGHT: Solids feeder on stream at pilot plant have been adapted to withstand a pressure of 30 psig. Vibra-Screw feeding unit at left is mounted on an Omega, 500-lb. beam loss-in-weight mechanism.

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World View



Visitors to the World's Fair are shown getting their first good look at the LEM (Lunar Excursion Module) Grumman is building for the Manned Space Center of the NASA.

As the World's Fair's technical exhibit in essence compose the "World of Tomorrow on View", the engineer and scientist is brought to the forefront. At Grumman this sense of participating in the future with a management who continually thinks towards the future, has made for an unusually stable environment. This stability supplemented by recognition and reward, without which any creative drive must soon founder, adds further nutrient to professional appetites. Here then is the opportunity. Engineers and scientists are urged to explore opportunities in the following areas:

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- Mission Analysis
- System Synthesis & Analysis
- Data Processing Systems
- Systems Integration
- Sensor Systems
- Control Systems
- Systems Simulation
- Programming
- Programming Analysis
- System Test Planning & Coordination

RELIABILITY CONTROL
- Component Parts
- Reliability & Maintainability Engrg.
- Reliability Test
- Reliability Statistics

DYNAMIC ANALYSIS
- Guidance Dynamics
- Control Dynamics
- Space Dynamics
- Acoustics & Environmental Vibration

POWER PLANT & ENVIRONMENT
- Environmental Control & Life Support Design & Test
- Space Power Plant Design & Test
- Fuel Cell Test
- Cryogenic System Design & Test

COMPUTING SCIENCES
- Digital Programming (7094)
- Mathematics
- Computer Design of Analog Support Equipment

THERMAL CONTROL & PROPULSION
- Heat Transfer & Thermo Dynamics
- Rocket System Performance Analysis
- Fluid Mechanics/Gas Dynamics

FLIGHT TEST
- Test Analysis
- Launch Operations
- Systems

INSTRUMENTATION
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- Measurements & Transducers
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DATA PROCESSING
- Program Analysis & Support
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- Video Simulation
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- Electronic Field Engineering

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- Preparation of Electronic Performance & Test Specs. (AFSCM 375 Method)

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To arrange an immediate interview, SEND RESUME to Mr. P. M. Van Putten, Manager Engineering Employment, Dept. GR-86.

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HONEYWELL INSTRUMENTATION

Two New Instruments Expand Line of Strip Chart Recorders

PHILADELPHIA — Introduction of the *ElectroniK 16* wide-chart recording potentiometer and the *ElectroniK 19* portable laboratory recorder greatly increases the performance capability of Honeywell strip chart recorders for test facility and laboratory use.

The *ElectroniK 16* recorder is extremely convenient to install, maintain and use. It mounts directly into a 19-inch relay rack without adapters or filler panels and has a new, high-performance, transistor servo-measuring unit. Chart-changing has been greatly simplified and an optional chart transport, which can be preloaded, permits charts to be changed in approximately 10 seconds. The *ElectroniK 16* is available in single, two-pen or multipoint models.

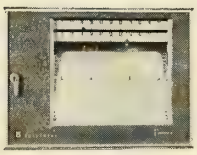
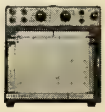
Mechanical layout of the recorder is such that most available options and accessories have their own unique locations on the chassis. Many options can be added later in the field—no need to return the instrument to the factory.

The *ElectroniK 19* portable lab recorder, a highly versatile instrument, is capable of measuring voltages from 100 microvolts full scale to 100 volts dc full scale without auxiliary equipment. Among other features, it has a tilting chart platen and thumb-wheel selection of 10 chart speeds.

The well-known *ElectroniK 17* recorder is ideal where mounting space must be conserved and accurate, low frequency dynamic measurements are required. The instrument features the infinite resolution *Stranducer* rebalancing element and solid-state circuitry. One or two independent full-width recording channels can be provided on a six-inch strip chart. Two chassis, each with one or two recording channels, allow recording of up to four independent channels in only 14 inches of vertical space in a standard 19-inch relay rack.

The *ElectroniK 18,* a single-pen, small-case recorder, is suitable for many demanding assignments, where equipment cost must be minimized.

ABRIDGED SPECIFICATIONS FOR STRIP CHART RECORDERS

				
	ElectroniK 16 (Single, Two-Pen and Multipoint Recorder)	ElectroniK 17 (2, 3, or 4-Pen Recorder)	ElectroniK 18 (Single-Pen only)	ElectroniK 19 (Single and Two-Pen)
Calibrated Accuracy	±¼ of 1% of span for mv ranges	±¼ of 1% of span	±3/10 of 1% of span	±¼ of 1% of span or 1 microvolt, whichever is greater
Dead Band	0.1% of span	0.15% of span	0.2% of span	0.15% of span
Chart Speeds	From ½ inch/hr. to 4 inches/second	½ to 480 inches/hr. single speed; up to 3600 inches/hr. with jump speed	½ to 120 inches/hr.	10 indicated speeds from 10 minutes/inch to 1 second/inch plus "stand-by"
Chart	11-in. calibrated width, 122 ft. long	6-in. calibrated width. 126 ft. long	6-in. calibrated width, 126 ft. long	6-in. calibrated width, 126 ft. long
Span Step Response Time	1 second full scale	1 second full scale	1 second full scale	Less than 0.5 second full scale
Calibration	D-C voltages and currents, thermocouple, radiation pyrometer, resistance thermometer, tachometer	D-C voltages and currents, thermocouple, radiation pyrometer, resistance thermometer, tachometer	Thermocouple, radiation pyrometer, millivolts, milliamperes	D-C voltages
Ranges	Minimum 1 millivolt full scale Maximum 300 volts full scale	Minimum 1 millivolt full scale Maximum 300 volts full scale	Minimum 1 millivolt full scale Maximum 100 millivolts full scale	0.1, 0.2, 0.5, 1.0, 2.0, 5.0, 10, 20, 50, 100 millivolts full scale and 0.2, 0.5, 1.0, 2.0, 5.0, 10, 20, 50, 100 volts full scale
Approximate Weight	85 lb.	Single chassis 46 lb. Dual chassis 116 lb.	46 lb.	Less than 20 lb.
Price Range (no options included)	$1000—1975	$755—2680	$615	$1100 net
Circle reader service card #	25	26	27	28

(All prices and specifications subject to change without notice.)

HONEYWELL, Philadelphia Div., Philadelphia, Pa. 19144 • Denver Div., Denver, Col. 80217

NEWS

MILITARY EDITION

Number 3-MI

Four *Visicorder* Oscillographs Offer Flexibility in Dynamic Data Recording

DENVER—Honeywell's line of direct-recording *Visicorder* oscillographs now includes models to fit almost every conceivable data recording need in the aerospace and scientific areas.

The 36-channel Model 1612 instrument, for instance, is available in a configuration that meets rigid military specifications for radio frequency (RFI) suppression. Another optional feature of the Model 1612 permits use of the new Eastman *Ektaline* and Du Pont fast-processing develop-out papers, as well as conventional photographic recording papers.

The Model 1508, like the Model 1612, is designed for rack-mounting in data systems. It records up to 24 channels of data simultaneously, yet occupies only seven inches of rack height.

The Model 1108, the most complete 24-channel oscillograph on the market, and the small, inexpensive Model 906, a 14-channel instrument, are designed primarily for bench use.

All four instruments are based on the Honeywell-developed principle of using ultraviolet light to record data on light-sensitive paper, thus providing instantly readable, permanent oscillographic records without chemical processing.

The accompanying chart shows the outstanding features of each instrument.

8 Graphic Recorders Fill Test Data Needs

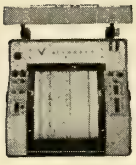
PHILADELPHIA—Eight graphic recorders now available from Honeywell's Philadelphia and Denver Divisions will satisfy most requirements for the recording of missile data falling in the DC-6000 cps range. The group includes four *Visicorder* oscillographs and four strip chart potentiometric recorders.

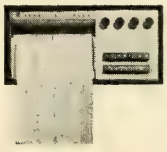
The wide choice of instruments available, along with the variety of options offered, enables users to select recording systems or individual units that will efficiently meet requirements. The instruments can be specified for rack or panel mounting, with laboratory feet, or for mounting in mobile consoles.

ABRIDGED SPECIFICATIONS FOR *VISICORDER* OSCILLOGRAPHS

HONEYWELL









	1612	1108	1508	906
No. of Channels	36	24	24	14
Paper Width	12"	8"	8"	6"
Paper Speeds	15—.1 to 160 ips	15—.05 to 80 ips	12—.1 to 80 ips	4—.4 to 50 ips
Frequency Response	DC-6000 cps	DC-6000 cps	DC-6000 cps	DC-6000 cps
Writing Speed	50,000 ips +	50,000 ips +	50,000 ips +	50,000 ips +
Record Reverse	Yes	Yes	No	No
Heated Platen	Optional	No	Optional	No
Latensifier	Optional	Optional	Optional	Optional
Paper Takeup	Built-in	Built-in	Optional	Optional
RFI Qualified	Yes—Optional	No	No	No
Develop-Out Capability	Yes	Yes	Yes	No
Gridlines	Built-in	Built-in	Built-in	Optional
Time Lines	Optional	Built-in	Optional	Optional
Trace Identification	Built-in	Built-in	Built-in—Optional	Optional
Trace Numbering	Optional	No	Optional	No
Galvo Intensity Control	Auto & Manual—Built-in	Manual—Built-in	Manual—Built-in	Optional
Remote Operation	Yes	Yes	Yes	Yes
Auto. Record Length Control	Built-in	Built-in	No	No
Paper Supply Indicator	Built-in	Built-in	Built-in	Built-in
Price Range	$7850-14,375	$4925-5275	$2775-5875	$1855-2700
Circle reader service card #	29	30	31	32

(All prices and specifications subject to change without notice.)

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Honeywell

phases are dissipated as they move through the mixing tube. The turbulent motion and continuous acceleration generated within the mixer tends to level out short-term feeding fluctuations.

The liquid phase is injected perpendicular to the high-velocity gas stream containing the solid particles at the mixer entrance. The kinetic energy of the liquid stream is used to penetrate the gas stream—subjecting the liquid to the high-velocity gas.

Introduction of the liquid takes place near enough to the tube mouth to prevent liquid droplet impingement on the tube wall. The cross-sectional area at the point of liquid introduction is sized so that the resultant velocity vector allows the liquid to converge outside of the tube. If this liquid sheet is significantly dense, it is effective in exposing a very high percentage of the conveyed solids to the liquid.

The demonstration facility constructed at NPP uses a specially modified Vibra-Screw feeding unit for oxidizer input. The unit, adapted to withstand a pressure of 30 psig, is mounted on an Omega, 500-lb. beam loss-in-weight mechanism. A similar unit can be used to feed ballistic modifiers or metal additives into the process stream.

A specially designed ejector entrains the solids from the feeders and exhausts them to the mixing units. Two metering pumps control the liquid flow of prepolymer and crosslinker to the mixing unit; an in-line mixer is used to blend the liquid ingredients before injection into the mixing tube.

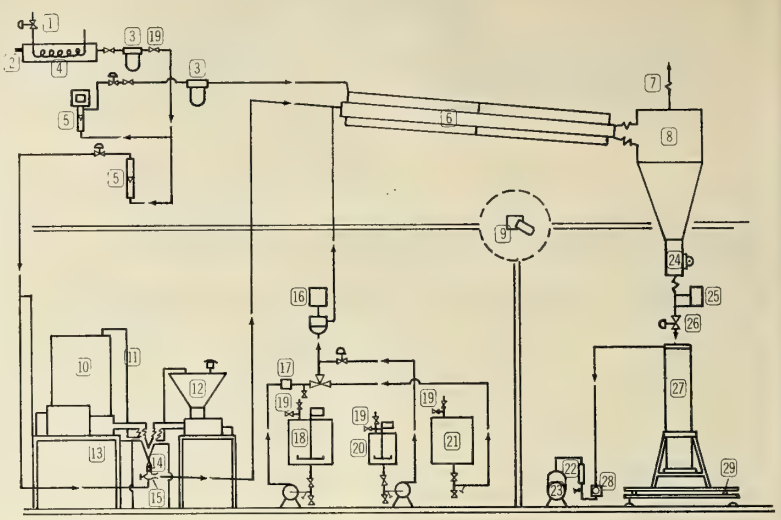
After passage through the mixing tube, the major portion of the entrapped air is separated in a high-efficiency centrifugal separator. A slit plate positioned just above the evacuated propellant mold serves as the secondary and final de-aeration step.

The elimination of the explosive hazard in pneumatic mixing is a great advantage of the system. The porous tube mixing eliminates all mechanical mixing—a factor which increases safety.

In addition, Colli says, the instantaneous mixing obtained minimizes the amount of explosive material within the mixing unit—less than 1 lb. at a production rate of 5,000 lbs./hr.

Neither the ratio of solids to liquid nor the viscosity of the liquid phase significantly decreases the mobility of the dispersed phases through the mixing unit since the carrier gas highly dilutes the material in the mixer.

● **Scale-up economical**—Colli says the production potential for the pneumatic mix process can be varied through design from a few hundred to thousands of pounds per hour. Should the propellent go off specification, the error can be detected and corrected within a minute, assuming adequate control mechanisms.



1 steam
2 air
3 filter
4 process air heater
5 air scfm
6 mixer
7 air exhaust
8 cyclone separator
9 tv camera
10 primary solids feeder lb/hr
11 pressure equalizer
12 secondary solids feed lb/hr
13 to purge seal
14 valve sight
15 ejector
16 in-line mixer
17 flow senser
18 polymer lb/hr
19 pr
20 crosslinker
21 solvent tank
22 trap
23 vacuum pump
24 vibrator
25 level controller
26 casting valve
27 casting unit
28 sight
29 weight senser

Colli maintains that the conditions for mixing a wide range of solid-liquid ingredients with the technique can eventually be predicted from the properties of the ingredients.

The speed, rate of breakup and critical size of droplets in gas streams have been theoretically correlated to the physical properties of the liquid phase in many areas of industrial technology. Numerous detailed scientific and engineering correlations have been established in the processing industries to determine the conditions for pneumatically transporting solids.

The more sensitive double-base propellant processes can be handled through another NPP process known as Inert Diluent. The Inert Diluent Process is a slurry method. All solid ingredients are introduced from pre-weighed hoppers to a disperser in which a dilute slurry is made up with an inert carrier.

Solid slurry is pumped from this tank to a mixing tee. Liquid ingredients are educted from a tank by a second stream of carrier and the two streams are mixed. The propellant is allowed to settle out and is then evacuated and cast. The IDP process is based on the Rocketdyne Quick-Mix method.

The IDP process uses inert liquid carriers, which usually are incompatible with some of the liquids used in composite processing. Thus the pneumatic approach is best for composites.

The pneumatic concept is a proven method. Propellant has been manufactured in the demonstrations facility and fired. The process lends itself easily to automation, but this obviously raises problems in quality assurance and control.

Quality assurance in automated processes is a new field in which a great deal of work is yet to be done. Another problem area is in the solids feeder section of the system. There are several approaches to this difficulty; NPP experts are evaluating both industrial feeder systems and some of their own ideas.

Industry acceptance of the pneumatic process has been good. ■

Minuteman Shock-Resistance Testing Scheduled for Next Year

by Willard E. Wilks

KIRTLAND AFB, N.M.—A technique for simulating ground shock effects of large nuclear air bursts on ICBM sites around the country is under development here, with full-scale tests on an operational *Minuteman* launch facility scheduled next year.

Ultimate objective envisioned is application of the technique to the hardened missile force to determine its vulnerability and survivability. The technique involves detonation of high explosives distributed on the ground over a facility.

If the method is successfully developed, the Air Force says, it will accomplish two critical aims that are either unattainable because of the test ban treaty or impossible from a practical standpoint:

—Provide a tool that will permit field proof testing—realistic simulation on complete, full-scale ICBM systems of the tremendous overpressures produced by nuclear air bursts.

—Enable for the first time a full-scale *in situ* check on existing individual hard sites around the country, an impossibility with nuclear devices even without the treaty.

"This will enable us to check operational facilities under realistic conditions without worry about disturbing any nearby communities," a spokesman told MISSILES AND ROCKETS.

● **Portability an advantage**—A major advantage of a full-scale portable technique is that it can be applied to operational sites anywhere. The testing problem is complicated by the fact that soil and geological characteristics vary considerably from site to site, so that predictions for one may not apply to another.

In developing the simulation method, the Air Force is mainly interested in duplicating the traveling wave effect resulting from overpressures emanating from the explosion source. This is produced by either air or surface bursts. Underground explosions present different problems and need not be simulated under the test ban.

The air burst problem is compounded because there are reinforcing effects produced by the traveling air blast wave feature, which feeds shocks into the ground at varying magnitudes and speeds as it moves out from ground zero. The result could be oscillations more damaging than the direct shock.

Final phase of the simulation development program calls for an Air Force Ballistic Systems Division technical staff to conduct the first full-scale tests on what spokesmen call "a real, live *Minuteman* facility." Air Force Weapons Laboratory (AFWL) here, which is developing the technique, will provide a scientific advisory staff.

● **Knowledge gap**—Air Force has been concerned for some time about acute lack of data in two areas:

—There has been little opportunity up to now to subject complete, full-scale systems to air blast-induced ground motions from a large yield nuclear weapon, to say nothing of even bigger weapons that may be downstream.

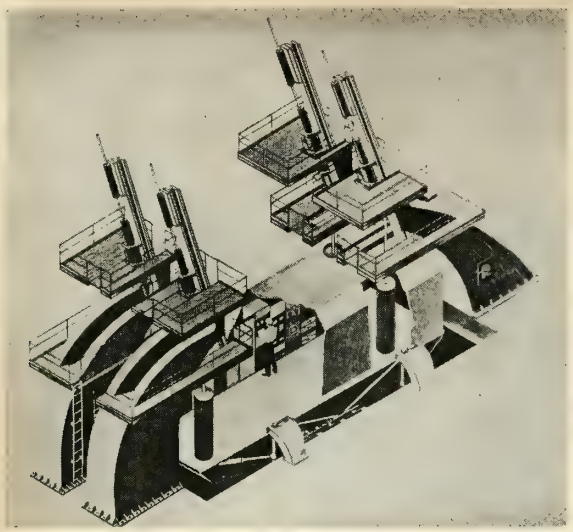
"We are on the frontiers of structural engineering," an Air Force source told M/R. "The critical area here involves things which go beyond the scope of conventional engineering, shocks far in excess of the natural environment."

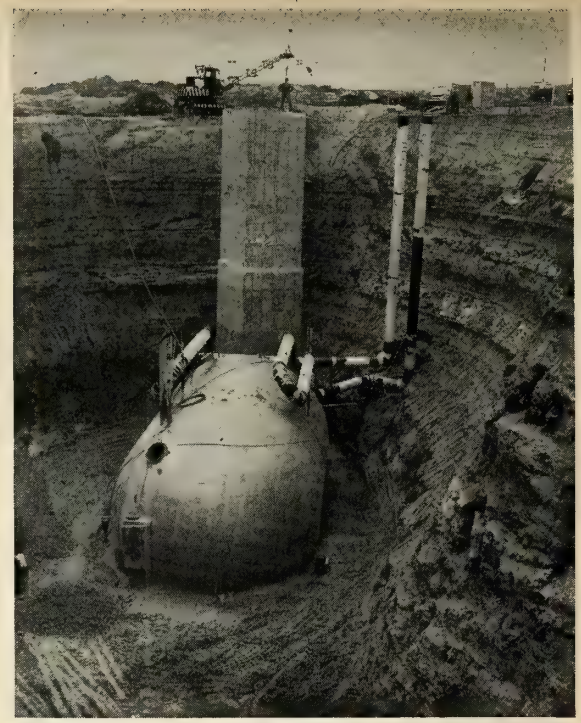
—Science lacks much basic knowledge about shock phenomena in the earth. The answer to this lack was overdesign.

"There has been much uncertainty about the behavior of soil and rock," another spokesman said. "But we feel great confidence. Many conservative assumptions have been built into the systems. We do have concern in the broad sense, reflected by the fact that

SIMULATION TEST shown here used gas-bag technique, now discarded, but tub-like structure will be used in upcoming "live" shock tests of Minuteman silo hardness.







ABOVE: Drawing of new Air Force Systems Command facility in which nuclear shocks will be simulated at Kirtland AFB. Scheduled for early testing in the facility will be the shock isolation system for underground ICBM launch control center. RIGHT: Minuteman ICBM launch control center during construction. Capsule is nearly complete and ready to be covered with earth. Chimney-like structure is an elevator shaft.

we're carrying on extensive research in this area. But we are not pessimistic."

An example of what analytical studies can produce is a recent investigation sponsored by AFWL at California Institute of Technology. According to the study report, it was discovered that a shock wave from a nearby nuclear burst would induce reverberations —identified as a "bell-ringing effect"— in a silo that may be more damaging than the shock wave itself.

High-intensity waves with energy comparable to that of the shock wave move rapidly in opposite directions around the cavity (silo) walls, and at points where the waves cross each other in phase, their energy is doubled.

• **Two approaches**—AFWL has made a comprehensive appraisal of many different simulation techniques both for degree of simulation and cost. The various techniques can be divided into two broad categories, those which try to match the features of a traveling air blast wave as closely as possible (traveling wave), and those which simply attempt to apply the desired load to the soil (plane wave).

Of those investigated, the traveling wave method achieved by the distributed high explosives approach currently shows the most promise. It will be used for the "live" *Minuteman* test if successfully developed.

AFWL recently shelved an approach using a plastic bag filled with detonable gases as being too dangerous to handle. The lab had conducted a number of tests in its gas bag facility, consisting of a 4-ft.-high reinforced concrete structure with a rectangular plane area 20 x 40 ft.

The same facility now is being used for work on the new concept, which uses primacord woven back and forth over a framework built about 3 ft. off the earth bottom of the rectangular pit. The primacord, with a detonation rate of about 21,000 fps., is strung across the framework at an angle so that the actual detonating front perpendicular to the base of the test surface moves at about 5,000 fps.

The first shot produced a 500-psi wave with only air under the primacord network as an attenuating material. Overpressures of more than 1,000 psi can be obtained. Or, with addition of an attenuating material, the overpressure could be brought down to 300 psi. This compares with the overpressure level and shockwave velocity experienced at about 2,000 ft. from a one-megaton weapon explosion.

A surcharge of dirt is used to cover the explosion to confine the products long enough to realize the full pulse duration. The result of this so-called quasi-continuous technique is to give a quasi-front that appears to be traveling in the desired direction at the right velocity.

Greatest advantage of the approach, for realistic simulation purposes, is that the shock wave contacts the ground at an oblique angle because of its travel through the attenuation medium, depending on the medium. Another advantage is its cost—$150,000 to $200,000 to conduct an experiment on an area 200 x 400 ft.

In tests at actual sites, an explosion area of 400 x 400 ft. has been considered. A factor yet to be determined in the simulation research is just how large a ground area is being loaded with a given size simulation structure.

Blast wave features of concern include overpressure, shock velocity, duration and pulse shape, shock pressure, and velocity decay.

• **Three-phase development**—Development of the simulation technique is being undertaken in three phases. Phase I covers refinement of the technique. Phase II, scheduled to start in October, will demonstrate feasibility of the method on a medium-scale, 100 x 200 ft., using all of the construction techniques, procedures and concepts selected for the test of an operational facility, and differing only in the scale of the experiment. A quarter-scale *Minuteman* silo may be used in this phase to develop similitude relationships.

Instrumentation will measure the "air blast" characteristics, mass of soil realistically influenced, and free-field ground motion. This phase is scheduled for completion in January.

In Phase III, the full-scale tests on a selected *Minuteman* facility will be carried out. In these tests, and in follow-on field work at ICBM sites, the technique must be applied to major components—launch control center, silo—

separately, since these components are located so far apart. The simulation device would be built on the ground directly over the facility component being tested.

Defense Atomic Support Agency provided $250,000 for the first two phases of the program. Phase III will be funded entirely by Air Force. BSD requested $3.3 million for the work in FY 1965-66. A large percentage of these funds is earmarked for measurements of the free-field and structural response for analysis of the system and extrapolation to other sites.

Simulation techniques ruled out in the AFWL studies included the gas cloud approach in which high-energy fuel is vaporized into the atmosphere and detonated.

Another simulation facility planned by AFWL is a 3,000-ft. tunnel that would be bored in a mountain near Kirtland. Architectural engineering contracts have shown feasibility of this giant shock tube. It would be at least 20 ft. in diameter to accommodate fair-sized models of silos and other structures. It would produce about 1,000 psi.

Central portion of the tunnel, on which AFWL would be prepared to begin work as part of the military construction program in 1967, would be for soil tests, with structural models buried in various types of soil. Another section of the tunnel would be used to test blast effects on re-entry models.

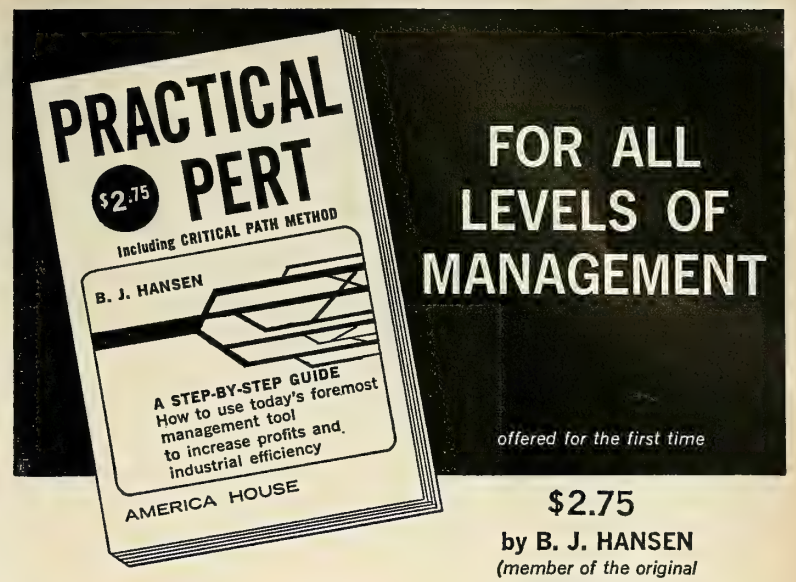
AFWL already has a 6-ft.-dia. 246-ft.-long horizontal tube of 100 psi capability, and smaller tubes, including a 13-in. facility that produces 1,000 psi.

● **Completed tests "impressive"**—Despite concern over lack of full-scale *in situ* test data, proof testing already performed with existing simulation devices is highly impressive. AFWL devices include the Air Force's biggest workhorse, a facility used for proof-testing the full-scale launch control center (LCC) shock isolation system and the launch equipment room sway dampers for *Minuteman* wings.

In a letter of commendation, AFWL was told the facility had enabled *Minuteman* site activation and was urgently needed for possible changes and future designs.

The huge facility, which has 380 yards of concrete reinforced with 20,000 lbs. of steel in its base, closely simulates the direct and air-induced ground shock effects. The non-linear device has tested *Minuteman* systems at 153 g, the figure provided by Strategic Air Command. This input could be doubled and acceleration transmitted to the LCC platform would still total only 0.6 to 0.7 g.

● **"Workhorse" described**—The device consists of four main actuators



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by B. J. HANSEN

(member of the original Polaris-PERT Team)

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positioned around a platform simulating the operational LCC. The platform is suspended from the structure by the shock isolation system under test. Two horizontal actuators are mounted on the side of the platform to provide input to the isolation system sway dampers.

The 153-g acceleration is obtained in less than 0.01 sec. by application of 1,310-psig gas pressure to an impulse piston. The deceleration phase lasts about 0.160 sec., with an entire cycle requiring about 0.87 sec. The simulated LCC platform load weighs 62,360 lbs., and the facility has worked with 85,000 lbs.

Eventually, AFWL will test platforms with animals and then men. The facility's energy input can be stepped up five times the level used currently, and it will be used to test shock isolators to destruction.

In its advanced research, AFWL has studied "superhard" missile offensive systems that could survive considerably larger yield devices.

In allied work, investigation has shown feasibility of a post-attack command and control system site (PACCSS) that would be buried at a depth of 5,000 ft. Criteria call for such a site to withstand any conceivable nuclear attack, even repeated pounding.

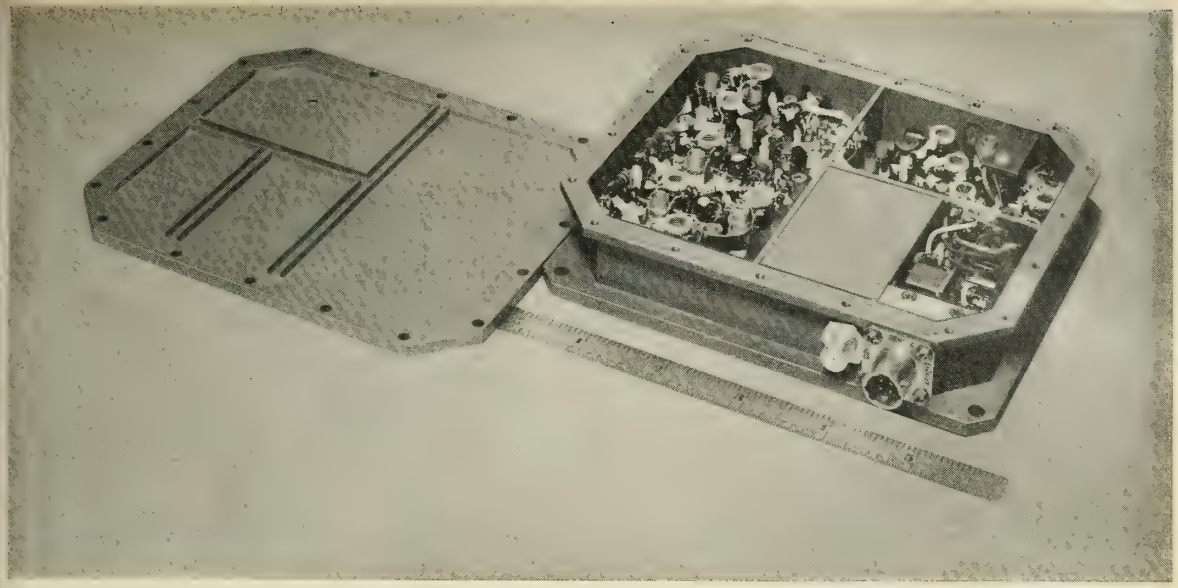
• **New nuclear test site**—Other Air Force simulation work involving military effects tests of many kinds at much higher yields than heretofore possible at the Nevada Test Site will be going forward at a new underground nuclear test location in Nevada.

The new site is on Pahute Mesa in the northern area of the test site and will enable nuclear detonations up into megaton range. The old site has been limited to around 300 kiloton devices to avoid disturbing Las Vegas.

At Pahute Mesa, which is 7,500 ft. high, Atomic Energy Commission is drilling holes 4,500 ft. deep and up to 100-in. diameter. Off the main shaft numerous tunnels are drilled at different heights and directions, resulting in a "Christmas tree' configuration. Military systems can be subjected to various effects tests in the side tunnels, with the main shaft used many times.

Air Force also has been making extensive use of theoretical programs in its nuclear simulation work. In a statement concerning its mission, AFWL reports:

"Our experience during the last moratorium bears out the importance of conducting strong theoretical and simulation programs during periods when testing is not permitted. Such programs not only advance our knowledge, but they also permit the development of well-planned . . . test programs that can be implemented on short notice." ■



MINIATURE S-band telemetry transmitter delivers five watts at nominal operating point.

space electronics

Miniature S-Band Units Delivered

Conic's five-watt telemetry transmitter being turned out on production-line basis in anticipation of 1967 switch

by Rex Pay

SAN DIEGO, CALIF.—Miniature five-watt S-band telemetry transmitters weighing about 3 lbs. are being manufactured on a production-line basis by Conic Corp.

Units have been delivered to Lockheed Missiles & Space Co.

With missile and space telemetry slated to move to S-band in 1967, launch vehicle and spacecraft manufacturers are already starting to specify S-band telemetry on bids. All of a sudden, 1967 does not seem so far away, and there is a lot of fresh interest in S-band equipment.

The Conic transmitter, type UHF-2, measures 5⅝ in. x 4⅝ in. x 1 5/16 in. It is, in fact, half as big as was stated in tentative specifications issued about nine months ago. The unit was developed by coupling a previously available VHF transmitter with a varactor multiplier and a newly developed modulator.

All three modules are built on printed circuit boards.

● **Performance**—Hermetically sealed, the transmitter operates over a —30° to 80°C temperature range and down to orbital pressures. Shocks of 100 g for 11 milli-seconds can be accepted. Vibration of 20 g peak, 20-20,000 cps, in any axis, generates FM noise at a maximum of 40 db below maximum carrier deviation.

The five-watt output is delivered at 25°C with a 28-volt power supply. If the supply voltage drops to 22.5 volts, the output reduces to 3.8 watts. The transmitter is designed to operate into a 50-ohm load, but is not damaged by short- or open-circuit conditions at its antenna terminal.

From a crystal oscillator output at about 28 mc, doublers and quadruplers give a carrier at 380 mc. A power amplifier with redundant transistors then boosts the signal level to 15 watts. Each transistor in the PA runs at about 40% of its rated dissipation. If one transistor fails, the transmitter will continue to operate at reduced power.

The 15-watt, 380-mc signal then passes to a tripler varactor, a doubler varactor, and finally to a 2.2. gc resonator. All these units fit into a volume of less than 3.25 cu. in.

● **Development problem**—In developing the unit. Conic experienced trouble with varactor diodes that dropped in efficiency as they aged. Main problem seems to have been optimistic power ratings by the diode manufacturers. Availability of improved varactor diodes would mean higher power outputs from the present transmitter.

The modulator portion of the transmitter has a response extending from dc to 1.5 mc. It is a constant-bandwidth system, the carrier deviation being fixed at 1.5 mc. FM/FM telemetry and narrow-band television can be handled. With modification, broadband television could be transmitted.

Power requirements for the transmitter are specified as 28 ± 4 volts dc at 1.5 amps. A dc/dc converter is not used, but a current regulator clamps the power supply current at 1.5 amps as the supply voltage goes above nominal. ■

ComSat Board Awaits Senate Nod

Commerce Committee promises early consideration of President Johnson's nominees; 12 directors elected despite protests

by Suzanne Montgomery

THE SENATE Commerce Committee has promised quick action on President Johnson's three nominations to the Communications Satellite Corp. board of directors.

Although the committee said it would act "as expeditiously as possible," there was no definite assurance that approval would come before the end of this Congressional session.

Johnson's nominations—sent to the committee Sept. 23—are Frederick Donner, board chairman of General Motors Corp., George Meany, president of the AFL-CIO, and Clark Kerr, president of the University of California. Donner's term expires at ComSat's annual meeting in 1965. Meany will serve until 1966 and Kerr until 1967.

If the session ends before action is taken, the President can name the directors to recess appointments, effective until the new Congress convenes next year. They must then be renominated and approved by the Senate.

Johnson's announcement completed the 15-man board, which held its first meeting in Washington last week. Twelve other directors were elected at a lively and sometimes unruly shareholders' meeting Sept. 17.

Directors elected by the public (Series I) stockholders and certified after a requested recount of proxy votes are: Joseph V. Charyk, president of the corporation; Leo D. Welch, chairman and chief executive officer of ComSat; David M. Kennedy, chairman of Continental Illinois National Bank & Trust Co., Chicago; George Killion, president of American President Lines; Leonard H. Marks, attorney, Washington, D.C.; and Bruce G. Sundlun, attorney of Washington and Providence, R.I.

The six directors were members of the original incorporating board appointed by President Kennedy in 1962.

Series II directors elected by the common carriers include three representatives of American Telephone & Telegraph Co., owner of 29% of the Series II stock; two representatives of International Telephone & Telegraph Corp., with 10.5% of the stock, and one nominee of the Hawaiian Telephone Co.

They are Harold M. Botkin, James E. Dingman and Horace P. Moulton of AT&T; Eugene R. Black and Ted B. Westfall of ITT, and Douglas S. Guild of Hawaiian Telephone.

Haskins & Sells of Washington, D.C., were elected auditors for the corporation.

● **Bucking the board**—Proceedings of ComSat's first shareholders' meeting were at times disrupted by claims that the management was self-perpetuating because its six nominees were members of the original board. There were repeated pleas for greater representation of the "small" shareholder.

Fred Fisher, the only stockholder to issue proxy statements in his own behalf, was defeated in his attempt to gain a place on the board. He called for a recount of the proxy votes, which certified the election of the management slate. Fisher, who is from Philadelphia, said he held 100 shares of Series I common stock.

George H. Poirier, a stockholder from Woonsocket, R.I., who had previously filed suit in the U.S. District Court to block the meeting, announced that he would continue efforts to depose the new board, "both in and out of court."

Poirier had indicated that the interim board stacked the election in its favor and thwarted his attempt to solicit proxies toward his own election.

● **Welch outlines role**—In his first address to shareholders, Chairman Welch foresaw an important role for ComSat Corp. in a new era he termed the "information explosion."

The amount of communications over the North Atlantic, for instance, is growing at a rate of 20% per year, Welch said. History has shown that each time an improvement in service has been made, a rise in the volume of traffic has followed. The estimated increase in communications is great enough to utilize all the services offered by a satellite communications system as well as the cable and radio means of today, he said.

Corporation expenditures for 1964 are expected to be about $12 million, Welch told shareholders. In 1965, this will rise to around $70 million; in 1966, it will increase to about $100 million. Expenditures for 1967 will level off somewhere between $20 and $30 million, he predicted.

● **New signatories**—On the international level, three more nations have signed the agreements on the global commercial communications satellite system since they were opened Aug. 20. They are Norway, Switzerland and Germany, which brings the total to 13 countries and the Vatican City.

The agreements—which deal with organization principles for the joint venture and the commercial and operating aspects of the system—are open for signature to any member nation of the International Telecommunication Union.

The international interim committee, which sets policy for the system, will meet in Washington Sept. 29.

Chances for Soviet cooperation in the venture were further weakened by a bitter denunciation of the U.S.-proposed worldwide communications system by a representative to the International Astronautical Federation in Warsaw.

Ivan Cheprov, a Soviet attorney, told delegates that the international agreements being signed contained doctrines in direct contradiction to the United Nations declaration of principles governing activities of nations in outer space.

Expressing his personal views and not necessarily the official Soviet position, Cheprov asserted that since the U.S. has 61% of the quota of votes, "the country is therefore essentially the sole manager.

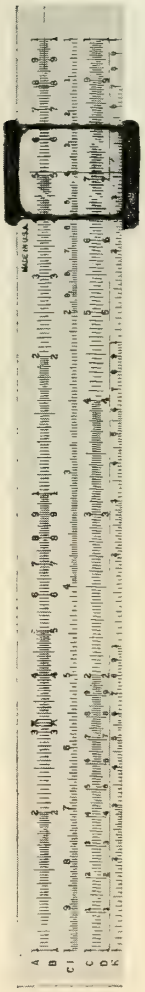
"Noting the strong position of American Telephone & Telegraph in the ComSat Corp., the organization is simply a private company with participation of foreign capital," said Cheprov. ■

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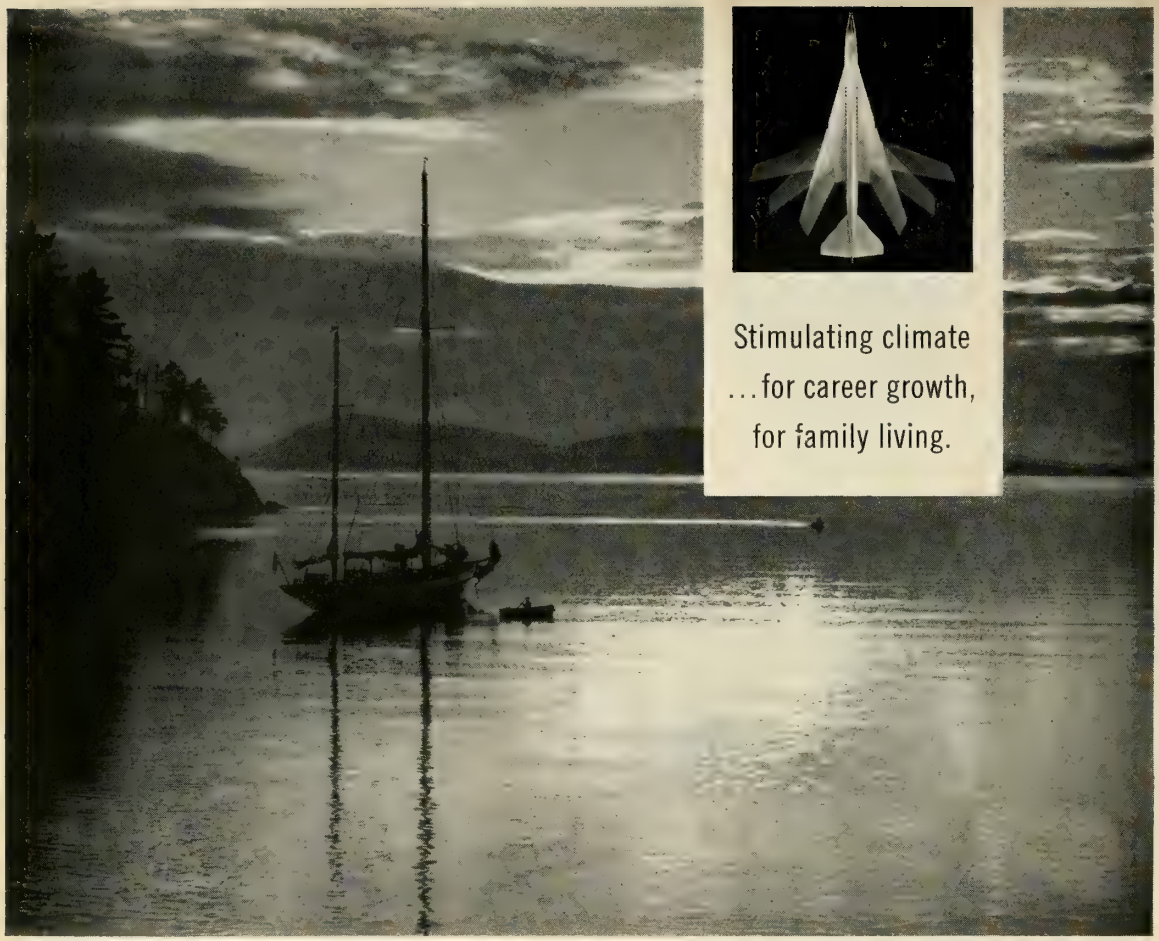
PHOTO BY P. DUNN



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Stability and Control Requires strong background in airplane flight control system design and analysis, and stability and control characteristics, plus knowledge of computers, servo-mechanism design and development and testing of airplane configurations. Master's degree or equivalent.

Flight Control Systems Assignments involve establishing dynamic design criteria and specifications for flight control systems, subsystems and components; selection of most suitable control system components, and guidance of control system procurement and flight test. Requires B.S. or M.S. in engineering, mathematics or physics with applicable experience.

Metallurgy and Mechanical Engineering Assignments entail alloy selection and application; development and improvement of processes; preparation of specifications; laboratory experiments; technical consultation, and service failure analysis. Requirements, in addition to experience in aircraft technology or a related field, include familiarity with the electron microprobe and microscope and standard metallurgical equipment.

Chemical Engineering Openings require experience in lubrication materials and concepts; elastomeric, inorganic finish, and organic polymeric materials, and structural adhesive bonding, plus a basic knowledge of materials behavior. Work involves evaluation, analysis and investigation of all materials characteristics, including mechanical, electrical, chemical and surface.

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The Industry Week

Mergers and Acquisitions

The boards of directors of The Marquardt Corp., Van Nuys, Calif., and Automation Laboratories, Inc., of Mineola, N.Y., have approved the acquisition of AL by Marquardt. The transaction, which remains subject to AL shareholders approval, would establish that firm as a Marquardt subsidiary. AL's principal activities are in related areas of television pickup and display equipment, visual scanning devices, precision angle measuring equipment, and radar simulation equipment. . . . *Technical Measurement Corp., North Haven, Conn., has acquired Vanguard Instruments Corp., La Grange, Ill., producers of chemical analytical equipment using radiochemical and ultraviolet absorption techniques. TM manufactures digital computors and instrumentation systems for the nuclear, biomedical, and telemetry data processing fields.* . . . Electronic Metals and Alloys, Inc., Attleboro, Mass., has acquired certain personnel and equipment from the Industrial Div. of the R. F. Simmons Co., also of Attleboro. EM&A will absorb the acquisitions in its Sweet Industrial Div. to improve its services in selling and servicing its custom and clad metals components in the aerospace, electrical, electronics and automotive industries. . . . *Dynaelectron Corp., Washington, D.C., has acquired the electronic countermeasures product line of TAMAR Electronics, Inc. Acquisition covers all developments, designs, patents, inventory, special tools, microwave test equipment, antenna range and environmental facilities associated with the line. Research, development and production of the countermeasures line will be relocated to the Pacific Div. of Dynaelectron at Gardena, Calif.* . . . Dressen-Barnes Electronics Corp., Pasadena, Calif., has acquired the assets of Omega Instrument Corp. of Altadena, Calif. Omega specializes in the manufacture of electronic pressure measuring equipment; D-B makes regulated direct-current power supplies. Omega is to be operated as a division of D-B.

New Activities

Spectra Strip Wire and Cable Corp., Garden Grove, Calif., has expanded into the fields of research, electronics and oceanography products with the introduction of its REO Div. The REO Div. is to encompass systems, components, assemblies, instrumentation, development, research, data acquisition and product lines. . . . *Bell & Howell Co. has formed a new subsidiary, the Bell & Howell Instrument Co., in San Juan, Puerto Rico. The Instrument Co. will manufacture precision components used in scientific and recording equipment produced by B&H's Electronic Instrumentation Group. Output of the new operation will be marketed in the U.S. and Canada by California-based subsidiary, Consolidated Electrodynamics Corp.* . . . Shareholders in the Perini Electronic Corp., Andover, Mass., and San Mateo, Calif., will be asked to ratify a change of the company name to DASA Corp. on Sept. 29. Perini is the manufacturer of MAGICALL, an automatic telephone dialer and other data communications equipment. The proposed re-naming is in the interest of avoiding confusion with the Perini Corp. of Framington, Mass., a construction company with no operational relationship to Perini Electronic Corp.

Missile/Space Facilities

Associated Testing Laboratories, Inc., Wayne, N.J., has completed installation of a Veeco Model MS-9 Helium Leak Detection Mass Spectrometer. The installation enables Associated to offer complete reliability and environmental testing service. . . . *Zero Manufacturing Co. has begun construction of a new 23,000-sq.-ft. office building in Burbank, Calif. Zero manufactures aluminum containers for the electronics and aerospace industries and other special products, including sub-miniature electronic parts, precision screws, racks and consoles.* . . . Optics Technology, Inc., a Belmont, Calif., optics research and development firm and manufacturer of electro-optical scientific and medical instruments, has announced plans to move early next year to Stanford Industrial Park, Calif. The building OTI will occupy affords 32,681 sq. ft. of space to house the R&D, engineering, manufacturing and administrative activities of the company. . . . *Industrial Electronic Engineers, Inc., manufacturer of rear-projection readout devices for visual data display, has moved into a new 34,000-sq.-ft. plant facility in Van Nuys, Calif. The plant will bring all IEE component manufacturing operations together under one roof.*

International

Hughes Aircraft Co. and the AB Bofors Co. of Sweden have formed the joint-venture firm, Bofors Elektroniskaaktiebolag, in Bofors, Sweden. The company will perform work in the fields of medical and chemical research, advanced research on infrared, as well as work in fire control, guidance and robot systems. The new firm will be owned and the board chosen on a 50-50 basis by Hughes and Bofors. . . . *France is actively considering the construction of a space launching base in French Guiana. From such a base the French could place satellites into polar as well as equatorial orbit.* . . . General Dynamics Corp. and Compagnie Générale de Télégraphic Sans Fils have announced the formation of a jointly owned company near Paris. The new firm, Societe d'Equipements Spatiaux et Astronautiques, will design and manufacture satellite tracking equipment. . . . *Mechatrol, a division of Servomechanisms, Inc., Westbury, N.Y., has concluded an agreement with Rotax, Ltd., Birmingham England, to market that firm's line of mechatrim precision metal film trimmer potentiometers in Continental Europe, the United Kingdom and the British Commonwealth, excluding Canada and the British West Indies.*

contracts

AIR FORCE

$18,248,754—**Thompson Ramo Wooldridge,** San Bernardino, Calif., for two contracts for continued development, production and installation of *Titan* and *Minuteman* missiles at Norton AFB.

$15,551,509—**General Dynamics Corp.,** San Diego, Calif., for continued work on *Apollo* boosters.

$11,687,200—**Mitre Corp.,** Bedford, Mass., for continued engineering work on various unspecified electronic systems.

$5,924,752—**Aerospace Corp.,** El Segundo, Calif., for continued engineering work on unspecified ballistic missile and space programs.

$4,500,000—**Collins Radio Co.,** Dallas, for 61 hardened high-frequency antenna systems for *Minuteman* sites.

$3,509,288—**Lockheed Missiles & Space Co.,** Sunnyvale, Calif., for R&D and production of unspecified space vehicles.

$2,433,000—**Aerojet-General Corp.,** Sacramento, Calif., for continued R&D on *Titan III* booster.

$1,500,000—**General Dynamics Corp.,** San Diego, Calif., for continued work on boosters.

$1,500,000—**Boeing Co.,** Seattle, for work on *Minuteman* missile systems at Vandenberg AFB, Calif.

$1,100,000—**General Dynamics Corp.,** San Diego, Calif., for design work on a space launch vehicle.

$1,100,000—**General Telephone & Eectronics Corp.,** Sylvania Electric Products Inc., Mountain View, Calif., for further development of electronic security systems to help guard *Minuteman* missile sites.

$1,024,723—**Air Products & Chemicals, Inc.,** Allentown, Pa., for LOX and liquid nitrogen.

$1,000,000—**General Motors Corp.,** Milwaukee, Wis., for work on the *Titan II* inertial guidance system.

$985,932—**General Motors Corp.,** AC Spark Plug Div., Milwaukee, Wis., for repair of accelerometer and 104 gyros applicable to the *CGM-138* missile weapon system.

$249,023—**Pickard and Burns, Inc.,** Waltham, Mass., for guidance and sensing techniques for advanced vehicles.

$218,465—**Philco Corp.,** Aeronutronic Div., Newport Beach, Calif., for re-entry ECM investigation.

$130,900—**Trustees of Columbia University,** New York City, for hydromagnetic plasma research.

$90,000—**General Telephone & Electronics Corp.,** Sylvania Electric Products Inc., Mounain View, Calif., for research on new laser communication techniques.

$86,470—**Hazeltine Corp.,** Little Neck, N.Y., for research on reliability and microelectronic techniques for anti-jam synchronous circuits.

$65,000—**General Dynamics/Electronics,** Rochester, N.Y., for continuation of work in thin-film measurement techniques.

$62,563—**Johns Hopkins University,** Baltimore, for high-resolution studies in the far infrared.

$60,671—**Boeing Co.,** Aero-Space Div., Seattle, for a strategic penetration study.

$60,000—**Avco Corp.,** Research and Advanced Development Div., Wilmington, Mass., for research program toward characterization of new ablative plastics and composites in advanced re-entry environments.

$49,646—**Ling-Temco-Vought, Inc.,** LTV Astronautics Div., Dallas, for research on guidance control and associated dynamics.

$46,910—**Construction Equipment Co., Inc.,** McPherson, Kan., to maintain missile project *Tiger Cat.*

$46,000—**General Dynamics Corp.,** Astronautics Div., San Diego, Calif., for scale model of a technique for measurement of propellant quantity.

$43,631—**Sylvania Electronic Products Inc.,** Williamsville, N.Y., for an advanced retrodirective antenna system.

ARMY

$11,587,000—**Morrison-Knudsen Co., Inc., Paul Hardeman, Inc.,** and **Perini Corp. of South Gate, Calif.,** a joint contract to erect a 400-ft.-high arming tower at NASA's Moon port now under construction at Kennedy Space Center, Fla.

$3,000,000—**Philco Corp.,** Aeronutronic Div., Newport Beach, Calif., increment to a previously awarded cost-plus-fixed-fee contract for continued research and development of the *Shillelagh.*

$777,555—**Action Manufacturing Co.,** Philadelphia, for rocket fuzes.

$362,861—**Bendix Field Engineering Corp.,** Owings Mills, Md., for 90-day extension of existing contract for logistical support services at the Green River Test Complex, Utah.

$100,750—**Aero Geo Astro Corp.,** Alexandria, Va., for C-band radar transponder.

$77,208—**Space Data Corp.,** Phoenix, Ariz., for telemetry packages to be used in conjunction with feasibility and design configuration study on families of rocket vehicles.

$41,106—**Western Electric Co.,** New York City, for *Nike* concurrent repair parts.

$26,221—**Western Electric Co.,** New York City, for procurement of *Nike* concurrent repair parts.

NAVY

$30,000,000—**Hughes Aircraft Co.,** Culver City, Calif., for continued work on *Phoenix* air-to-air missiles.

$1,684,443—**Honeywell, Inc.,** Aeronautical Div., St. Petersburg, Fla., for 100 additional MK II Mod 0 pulse integrating gyro accelerometers for *Polaris.*

$716,000—**General Electric Co.,** Pittsfield, Mass., for *Polaris* portable guidance test equipment.

$249,000—**Bendix Corp.,** Systems Div., Ann Arbor, Mich., for an operations analysis and feasibility study of a proposed new weapon system program.

$101,820—**Standford Research Institute,** Menlo Park, Calif., for R&D to determine the viscoelastic properties of solid propellants and propellant binders.

$99,231—**Sperry Microwave Electronics Co.,** Clearwater, Fla., for necessary services, labor and material and equipment to design, fabricate and test X-band antenna and radome.

$49,654—**Space General Corp.,** El Monte, Calif., for an attitude control system.

$43,460—**Federal Scientific Corp.,** New York City, for instrumentation and consultant services for FBM flight test program.

$40,014—**Bermite Powder Co.,** Saugus, Calif., for destructor charge for a missile.

NASA

$11,000,000—**Hayes International Corp.,** Birmingham, Ala., for 29 service arms to be used on launch towers in the *Apollo* program.

$1,000,000—**Beckman Instruments, Inc.,** Richmond, Calif., and Scientific Data Systems, Inc., Santa Monica, Calif., joint contract for an analog-digital computer system to stimulate the actual conditions of space flight.

$800,000—**Consolidated Electrodynamics Corp.,** Pasadena, Calif., for 1.5-mc magnetic tape recorders.

$110,900—**Monitor Systems, Inc.,** Ft. Washington, Pa., for PCM data handling systems.

$77,460—**Atlantic Research Corp.,** Duarte, Calif., for *Nike-Apache* hardware.

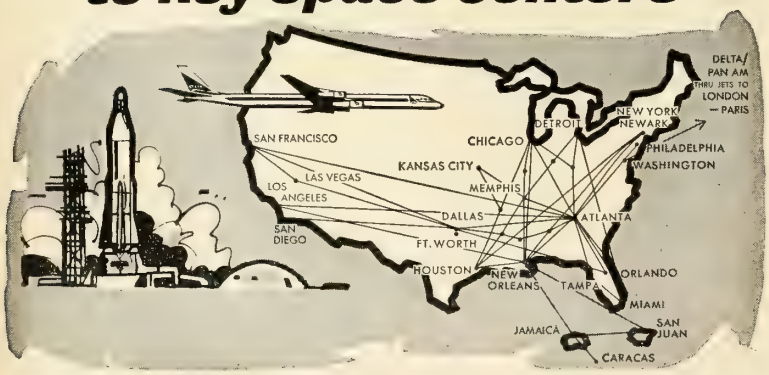
INDUSTRY

$750,000—**Fairchild Camera and Instrument Corp.,** Precision Metal Products Div., El Cajon, Calif., from **North American Aviation,** Space and Information Systems Div., Downey, Calif., to design, test and manufacture LOX and liquid hydrogen flexible metal ducting for the *S-II* stage of NASA's *Saturn V Apollo* booster.

$650,000—**Swedlow Inc.,** Los Angeles, from **North American Aviation, Inc.,** Rocketdyne Div., McGregor, Tex., for motor case insulative liners for the Navy's *Sparrow III* air-to-air and *Shrike* air-to-ground guided missiles.

$500,000—**Straza Industries,** El Cajon, Calif., from **North American Aviation,** Space and Information Systems Div., Downey, Calif., to test, develop and produce gaseous hydrogen mainfold assemblies for the *Saturn II.*

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New Product of the Week:

Solid-State Scope Plug-In

A new plug-in module that allows a standard line of high-frequency direct-reading oscilloscopes to handle signals of 100 mc with a nominal pulse rise-time of 3.5 nanosecs has been developed by the DuMont Laboratories of Fairchild Camera and Instrument Corp.

The module, according to Fairchild, becomes the first solid-state device of its kind to provide a 100-mc bandwidth and also the first to provide more bandwidth than comparable vacuum tube systems. The bandwidth capabilities represent an increase of 100% over the 50-mc solid-state plug-in offered by the firm last year. The new system uses solid-state components and CRT display units manufactured within Fairchild, thought the components are standard for ease of replacement.

Use of solid-state design has cut the weight of the entire oscilloscope assembly with the 100-mc plug-in to about 35 lbs. Fairchild believes that the system's portability is a major marketing advantage. The firm estimates that the market for oscilloscopes in the U.S.



alone is about $100 million annually.

The new plug-in, which features dual-trace performance with 10mv/cm sensitivity, fits all three main-frame configurations of the Fairchild 765 and 765H series oscilloscopes.

Circle No. 151 on Subscriber Service Card

Resistor Stop/Test Instrument

A resistor stop and test instrument that can be used to monitor and control the adjusting process for any metal film, carbon film or deposited resistor and tests the value of the finished resistor in the same sequence has been announced by Teradyne, Inc.

The Model R145 is completely dial programmable and has plug-in modules for tolerance selection. Test range is from 10 ohms to 11.999 megohms at full accuracy, with four-digit resolution obtained through four programming dials and a multiplier. Test tolerances of 0 to 10% can be programmed on a plug-in module and accuracies of 0.1% are available.

Circle No. 152 on Subscriber Service Card

Antenna Switching Matrix

Delta Electronics, Inc., is marketing a high-power antenna switching matrix utilizing a strip line technique for high performance characteristics in a compact configuration.

The Model SLS-1 is a 10 x 11 flexible switching matrix. Ten transmitters can be connected to any of 11 loads. The plunger type switching mechanism removes all residual stubs from active circuits. Power rating is 50 kw average from dc to 30 mcs. Characteristic impedance is 50 ohms with a VSWR of 1.15 or less and cross channel isolation exceeding 65 db.

The unit measures 65 x 60 x 20 in. and weighs approximately 350 lbs.

Circle No. 153 on Subscriber Service Card

Beryllium Copper Strip

American Silver Co., a division of Sherman Industries, Inc., has available ASCO-TIND, solder-coated beryllium copper strip material. The product may be solder-joined without the use of additional solder or corrosive fluxes.

The material may be ordered in all tempers of the base metal with a metallurgically bonded layer of pure tin or any of a broad range of solder alloys. The tin or solder layer may be specified in any thickness from 0.0002 to 0.003 in. on beryllium copper strip from 0.001 to 0.025 in. thick in widths between 0.25 and 3 in. Thickness tolerance can be as close as ±0.0002 in., the firm said.

Circle No. 154 on Subscriber Service Card

Information Filing System

A system for recording visual information with almost instantaneous playback accessibility has been developed by Machtronics, Inc.

The system utilizes a metal disc approximately 12 in. in diameter. Each disc has a storage capacity of 1,200 pictures, said to provide a virtually indestructible and permanent storage of information, which may be played back at will any number of times, with an accessibility rate of 500 pictures per second. Any picture can be erased and replaced with another at any time.

The system can be expanded to have a capacity in the order of 100 discs, providing a total storage of 120,000 pictures. The reproduced picture has a resolution of over 300 lines and a signal-to-noise ration of 40 db. It accepts any regular video signal and records one complete video frame (two interlaced fields) at a time. Maximum recording rate on the metal discs is 30 pictures per second.

Circle No. 155 on Subscriber Service Card

Environmental Chamber

A trailer-mounted environmental chamber for transporting rockets, explosives, inflammables and other items requiring delicate handling is available from Webber Manufacturing Co., Inc.

The Model WF-336-100/200X maintains any temperature from —100° to 200°F within ±2°F. Operating equipment and controls are enclosed for use in all weather conditions between —20° and 110°F. Temperatures are controlled and recorded by a thermocouple-type unit. Interior components, including light, heating elements and fan motors, are explosion-proof. Grooved trays on removable sliding racks permit convenient removal of the test load. Inside dimensions are 6 x 8 x 7 ft. Other sizes and temperature ranges are available.

Circle No. 156 on Subscriber Service Card

Hydrophone

The LC-34 hydrophone, felt to have possible applications in the field of anti-submarine warfare, is being marketed by Atlantic Research Corp.'s Electro-Mechanics Div.

The device features a sensitivity to —90 db (sensitivity db reference: 1v/microbar). Frequency response in water is 1 to 85,000 cps ±3 db. The unit is said to be static-pressure resistant up to 500 psi. Rated capacitance is 1,300 picofarads. Nominal charge sensitivity is 2,800 pc/psi and nominal voltage sensitivity with 5 ft. of low-noise cable is 2.2v/psi.

A broadband preamplifier adjacent to and in line with the hydrophone compensates for decrease in sensitivity due to extensive connecting cable.

The device has double-molded construction for maximum waterproof integrity. Dimensions are 4.28 in. long and 0.75 in. in diameter.

Circle No. 157 on Subscriber Service Card

Infrared Thermometer

Huggins Laboratories, Inc., has developed the Infrascope Mark II Radiation Thermometer that works without contact.

The hand-held instrument can be "aimed" at distant objects and picks up the radiant energy. This is instantly converted to temperature and indicated on a meter. The unit uses a lead sulfide photoconductive infrared detector and contains a built-in calibration source and battery check for maximum reliability and accuracy.

It weighs 2.5 lbs. and is available with ranges from —120° to 7,200°F. Indication may be in Fahrenheit or Centigrade.

Circle No. 158 on Subscriber Service Card

Frequency Synthesizer

Collins Radio Co.'s Dallas Div. is producing a compact universal frequency synthesizer for use in portable field communication sets.

The unit has a size reduction of approximately 100 to 1 compared to a conventional synthesizer, the firm says. It operates to 40 mc with a power consumption of four milliwatts. Operating in the HF frequency range, the unit consists of 410 semiconductor components and uses 33 thin-film circuits. It provides 1,000-cycle channel spacing and has a stability of one part in 10^8.

According to Collins, tests of the device have shown approximately 325,000 element hours without an element failure.

Circle No. 159 on Subscriber Service Card

Servo Tester

Industrial Control Co. is marketing the 100-C servo test that generates waveshapes necessary to measure both the



frequency and transient response of servo loops and their components.

All circuitry is transistorized and operation is directly from the 117-v, 60- or 400-cps line. All inputs and outputs go to individual terminals. Data frequency range is 0.02 to 60 cps. The three carrier frequencies used are 60, 400 and 2,500 cps. The unit is available for bench or rack installation.

Circle No. 160 on Subscriber Service Card

Telemetry Checkout System

Standard Precision, Inc., is marketing the Telecheck, a portable and automatic telemetry check out system capable of testing the 18 IRIG channel VCOs of a frequency modulated telemetry system in 2 minutes.

By applying a calibrated dc voltage to the VCO input, the device automatically checks the VCO output frequency to determine if it is within a selected boundary frequency. The system employs 5 uniform steps in testing each of the 18 number and 5 letter IRIG channels. Out-of-tolerance deviations stop the cycle. The boundary limits may be selected to accept a 1% or 2% error in output frequency. The system also contains a crystal oscillator for self-calibration.

Circle No. 161 on Subscriber Service Card

DC Voltage Standard

A dc voltage standard with 0.003% precision and 15-ppm stability has been announced by Cohu Electronics, Inc.

The Model 304 will deliver voltages from 0 to 1,222.2221 in steps as small as 1 mv with an accuracy of 0.003% of setting+10 mv. Stability is 0.0015% of setting +0.0001% of full scale for seven days. RMS noise voltage is less than 20 mv on the lowest range. Output current is 0 to 50 milliamps at any voltage setting.

Circle No. 162 on Subscriber Service Card

Microwave System

A solid-state microwave system designed for use on lower density routes is being marketed by Lenkurt Electric Co., Inc.

The 71F Microwave operates in the 2-gc industrial band and can accommodate up to 120 voice channels on the main carrier baseband. A minimum of eight voice channels can be stacked above the order wire for dropping off individual circuits at each repeater.

Specifications include a frequency range of 1,700 to 2,300 mc; frequency stability of 0.001%; total noise per hop, 18 dba0 (120 channel loading); power output, 1 watt nominal; and temperature range: —40° to 50°C.

Circle No. 163 on Subscriber Service Card

Precise Angle Indicator

A miniature precise angle indicator that reproduces and displays in digital readout any angular displacement as signalled by a remotely located synchro transmitter is being marketed by Gap Instrument Corp.

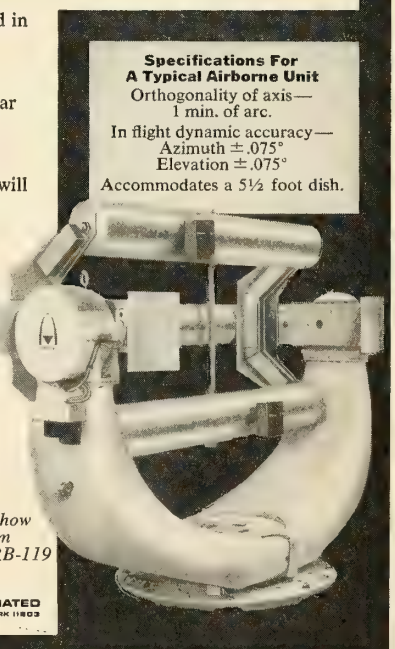
The Model S2000-111 shows displacement from 0 to 360 degrees continuously. Standard accuracy is ±6 minutes. The device meets MIL-T-21200D

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specifications and features synchro or potentiometer input, slew speeds of 25 degrees/sec. and repeatability of ±1 minute.

Circle No. 164 on Subscriber Service Card

Triggered Spark Gap

A ceramic-metal, medium-energy switch rated for use up to 600 joules at pulsewidths not exceeding 60 μsecs is being marketed by Edgerton, Germeshausen & Grier, Inc.

The Model GP-31A has an operational range of 2 to 6 kv. Most useful applications, the company says, are as a switch for a crowbar in medium power microwave systems, a main switch for magneto-optic shutters and for multiple exploding bridgewire initiating devices.

Circle No. 165 on Subscriber Service Card

Channel Analyzer

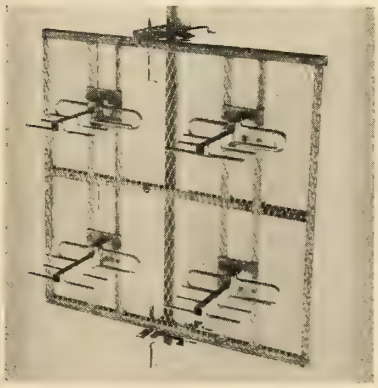
A multichannel pulse height analyzer system, the ND-181, has been announced by Nuclear Data, Inc.

The unit operates in three areas of scientific measurement—pulse height analysis, multichannel scaling and signal averaging. It consists of four components—an analog-to-digital converter, an arithmetic and memory unit, a readout control and an integrating and time base unit.

Circle No. 166 on Subscriber Service Card

Screen Reflector Yagis

Technical Appliance Corp. has available a series of high-gain screen yagis designed for communications and special purpose applications. Each model of the SY-44 series consists of a quad yagi array of horizontally polarized elements mounted above a single mesh surface ground plane.



Models are currently available for the frequency bands of 390 to 425 mc; 450 to 470 mc and 470 to 512 mc. The ground screen measures 48 x 36 in.

Circle No. 167 on Subscriber Service Card

LC Filter

An LC filter, miniaturized for space and military project communication and telemetry applications, has been developed by the Electronics Div. of Bulova Watch Co., Inc.

The BP521, a 70-kc bandpass filter, has an impedance rated at 10,000 ohms balanced input with 1,000 ohms output. Bandwidth at 3 db is greater than 21 kc and at 39 db is less than 41 kc, a 3 to 60-db shape factor of 2:1. Phase characteristic within the passband is linear to ±15 degrees.

The unit is being manufactured to MIL-F-18327 and NASA NPC-200 specifications. It can be supplied with any center frequency from 30 to 70 kc.

Circle No. 168 on Subscriber Service Card

C&C FM Transmitter

An FM transmitter specifically designed for command & control applications has been developed by the Instrumentation Div. of Microdot, Inc.

The Model 2345 operates in the 400 to 550-mc range with an output power of 100 watts. Frequency accuracy is ±0.005% with stability of ±0.001%. The unit meets vibration and shock specifications of MIL-E-5400F and interference specifications of MIL-I 6181 D. It weighs 100 lbs. and measures 19 x 12 x 16 in.

Circle No. 169 on Subscriber Service Card

Needle Valves

Circle Seal Products Co., Inc., has introduced a line of needle valves featuring unibody construction, packing below and threads and "coined" seat sealing.

According to the firm, the unibody construction eliminates body leakage and provides safety against the operator backing out of the bonnet of the valve under pressure. Packing below the threads results in low torque threaded stem movement above the packing, where lubricant is free from contamination. The coining process provides a maximum seat density for extra durability, the company maintains.

The valves are available in 316 stainless steel with ⅛, ¼ and ⅜ in. sizes. Operating pressure range is 0 to 3,000 psi at temperatures from —65 to 450°F.

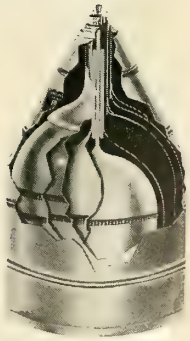
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BEYOND APOLLO—THE U.S. SPACE PROGRAM

MISSILES AND ROCKETS will publish its fourth annual NASA issue November 30, 1964. Now accepted as the authoritative publication on the nation's space agency, M/R will examine the National Aeronautics and Space Administration's current and future projects, people and facilities—plus NASA fiscal 1966 budget planning now being considered by the administration.

PUBLICATION DATE
NOVEMBER 30, 1964

ADVERTISING CLOSES
NOVEMBER 16, 1964

With major procurement for the Apollo manned lunar landing program now behind it, NASA is deep in the planning of new projects to expand man's knowledge in space. Special emphasis is placed in this issue on the U. S. Space Program—BEYOND APOLLO—with detailed descriptions of post-Apollo missions:

- Lunar Logistic Supply System
- Manned Orbital Research Laboratory
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- Manned and Unmanned Planetary Probes

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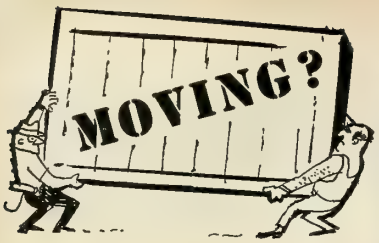
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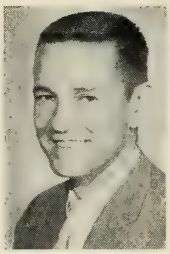
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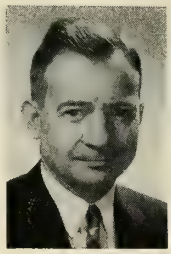
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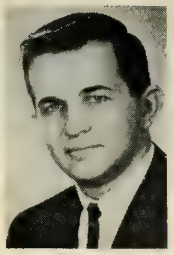
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names in the news


TAYLOR


STEVENS


GILLIS


CARRICO

James J. Kramer: Named project manager of the Large Solid Motor Demonstration Project at the National Aeronautics and Space Administration's Lewis Research Center, Cleveland. He will be responsible for the 260-in. solid propellant rocket motor program.

Hubert J. Taylor: Joined the western operation of Sylvania Electronic Systems, a division of Sylvania Electric Products, Inc., New York City, as manager of market planning and research. He will deal with future government markets and evaluate their business potential in electronics research, development and production.

Orville S. Tuttle: Appointed technical advisor to the general manager of Douglas Aircraft Company's Aircomb Div., Cudahy, Calif. Aircomb is a material used in the fabrication of aircraft, missiles, space vehicles and a variety of specialized industrial products.

Donald L. Stevens: Appointed director of Information Systems Dept., Philco Corp.'s Communications and Electronics Div., Philadelphia. He was formerly with Thompson Ramo Wooldridge Co.

Fred W. Morris, Jr.: Appointed Associate Director of Telecommunications Management in the Executive Office of the President of the United States. He is also on the Professional Staff of the National Aeronautics & Space Council.

Richard S. Fey: Named manager, advanced technical studies, for the Chemical Propulsion Div. of Hercules Powder Co., Wilmington, Del.

Richard J. Gillis: Appointed a technical representative in the Eastern District Office of Thiokol Chemical Corp., Bristol, Pa. He will represent the company with Goddard Space Flight Center, Langley Research Center and other NASA Headquarters research programs.

Elmer Hutchisson: Will retire as Director of the American Institute of Physics on Oct. 1. Simultaneously, he will return to the position of editor of "The Journal of Applied Physics," a scientific periodical he founded and first edited for the A.I.P.

O. Wayne Carrico: Appointed to the newly created position of Corporate Director of Commercial Development of Aerojet-General Corp., Washington, D.C. He will have responsibility for all commercial activity throughout the corporation.

George C. Tweed, Jr: Promoted to the corporate staff of Cubic Corp. as Director of Engineering in San Diego, Calif. He will establish engineering policy and coordinate all engineering activities as well as be a member of the management committee for long range planning.

Atlantic Research Corp., Alexandria, Va., has established a new corporate Field Sales Dept. It will be headed by **John T. Ticer** as Manager and **David B. Roberts** as Assistant Manager.

Douglas L. Hamilton: Elected vice president-finance of Sylvania Electric Products Inc., a subsidiary of General Telephone and Electronics Corp., New York City. Also elected was **Jay W. White,** Treasurer.

Leonard Schieber, Jr.: Appointed director of research at the Orlando Div. of the Martin Co., Orlando, Fla. He will direct the new Martin-Orlando Research Center and all fundamental and applied research programs of the Orlando Div.

Percy Halpert: Appointed vice president of Sperry Gyroscope Co., Great Neck, N.Y. He will be responsible for Sperry divisions concerned with guidance, navigation, avionics and missile system technologies.

R. Clinton Names: Joined Rocket Research Corp., Seattle, as Project Engineer. He was formerly employed with Lockheed Missiles & Space Co.

Paul J. Colleran: Appointed manager of silicon controlled rectifier operations for Motorola's Semiconductor Products Div., Phoenix, Ariz. He will be responsible for the engineering and production of silicon controlled rectifiers.

John Chang: Named manager of research and development of U.S. Polymeric Chemicals, Inc., Santa Ana, Calif.

Lewis J. Shioleno: Appointed vice president operations of Erie Technological Products, Inc., Erie, Pa. He will have responsibility for all phases of electronic components manufacturing and marketing in the U.S.

—when and where—

SEPTEMBER

First International Congress on Instrumentation in Aerospace Simulation Facilities, sponsored by the IEEE, l'Ecole Nationale Superieure de l'Aeronautique Paris, Sept. 28-29.

Symposium on Physics and Nondestructive Testing, sponsored by the Southwest Research Institute, Biltmore Hotel, Dayton, Ohio, Sept. 29-Oct. 1.

Third Annual Symposium on the Physics of Failure in Electronics, sponsored by the Illinois Institute of Technology Research Institute, Grover M. Hermann Hall, Chicago, Sept. 29-Oct. 1.

OCTOBER

Fourth National Symposium of the Society for Information Display, Shoreham Hotel, Washington, D.C., Oct. 1-2.

1964 Annual Meeting of the American Documentation Institute, Philadelphia, Oct. 4-8.

Second Annual Research Management Program, sponsored by the Battelle Memorial Institute and Ohio University, Battelle Memorial Institute, Columbus, Ohio, Oct. 4-16.

National Symposium on Space Electronics and Telemetry, sponsored by the IEEE, Dunes Hotel, Las Vegas, Oct. 4-9.

Third Annual USAF Contract Aerospace Services Symposium, sponsored by the National Aerospace Services Assoc., Dayton Biltmore, Dayton, Ohio, Oct. 5.

10th National Communications Symposium, sponsored by the IEEE, Utica, N.Y. Oct. 5-7.

10th Annual Army Human Factors Research and Development Conference, Fort Rucker, Ala., Oct. 5-8.

Parameters of Information Science, sponsored by AFOSR and the American Documentation Institute, Sheraton Hotel, Philadelphia, Oct. 5-8.

National Aeronautic and Space Engineering and Manufacturing Meeting, sponsored by the Society of Automotive Engineers, Ambassador Hotel, Los Angeles, Oct. 5-9.

Seminar on Quantum Mechanics, sponsored by the American Institute of Physics and the National Association of Science Writers, Inc., Hotel Statler-Hilton, New York City, Oct. 6.

International Space Electronics Symposium, sponsored by the IEEE Space Electronics and Telemetry Group, Dunes Hotel, Las Vegas, Oct. 6-9.

Electronic Information Handling Conference, sponsored by the University of Pittsburgh, Goodyear Aerospace Corp., and Western Michigan University, Hotel Webster Hall, Pittsburgh, Oct. 7-9.

Galileo Quadricentennial, sponsored by the University of Rochester and the National Science Foundation, University of Rochester, Rochester, N.Y., Oct. 8-9.

Society of Plastics Engineers, Inc., Regional Technical Conference, Sheraton-Cleveland Hotel, Cleveland, Ohio, Oct. 8-9.

Refractories Div. of the American Ceramics Society Fall Meeting, Cavalier Hotel, Virginia Beach, Va., Oct. 8-10.

Electrochemical Society Meeting, Sheraton Park Hotel, Washington, D.C., Oct. 11-15.

Flight Mechanics and Entry Technology Meeting sponsored by the AIAA and NASA, Convention Center, Williamsburg, Va., and Langley Field, Va., (meeting at Langley is Classified), Oct. 12-13.

Second Aerospace Nuclear Propulsion Conference (partly Classified), sponsored by the American Nuclear Society, AIAA, Atomic Energy Commission, and NASA, Naval Postgraduate School, Monterey, Calif., Oct. 12-15.

Symposium on Dosimetry in High Level Exposure, International Atomic Energy Agency, Vienna, Austria, Oct. 12-16.

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The Briefing

"GOOD MORNING, COMRADES. Good morning, General. You may proceed."

"Good morning, Mr. Chairman. There have been some interesting developments. You will recall from last week's briefing on the United States that we still were puzzled by the unusual radar antenna photographed by the *Cosmos* satellites at Patuxent in the state of Maryland. That now has been identified as a new American over-the-horizon radar which will increase warning time by spotting missiles immediately after launch."

"Splendid work. Who was the agent?"

"The radar was identified by the President of the United States, Mr. Chairman."

"Incredible."

"Indeed, Mr. Chairman, but true."

"I assume, General, that this latest development will significantly increase their anti-missile capability."

"Not at all, Mr. Chairman. The Americans still have no anti-missile capability. The American Secretary of Defense says development of what they call the *Nike-X* system has exceeded his fondest hopes. He notes, however, that it would cost between $15 and $20 billion to deploy the system to protect from 20 to 30% of the American population. There is some question as to whether they will spend this."

"But have I not read that the Americans spend more than that each year on liquor, cigarettes and cosmetics?"

"Quite true, Mr. Chairman, but there is doubt whether their Administration will fund such a program to protect their lives."

"Incredible. Am I to assume, then, that the additional warning time will be invaluable in permitting the citizens to reach their shelters sooner?"

"No, Mr. Chairman. The Americans have no civil defense program."

"Incredible. But why are they spending such vast sums then on an over-the-horizon radar? What possible use can it be?"

"The analysis section still is working on that, Mr. Chairman. It should be noted, however, that vast sums are not credited for the new radar. The American secretary says its development cost only $50 million."

"Truly incredible. Why can we not match such economy?"

"We are studying that, Mr. Chairman. It appears the American secretary has two accounting systems. One for those projects he favors. One for those he does not. The former are most economical, the latter are most extravagant. It is indeed puzzling."

"Proceed."

"We can now affirm, Mr. Chairman, that reports in the American technical journals of anti-satellite systems deployed in the Pacific are true. These reports have been confirmed without question within this past week."

"What is the source for this intelligence?"

"The President of the United States, Mr. Chairman."

"Incredible, but usually unimpeachable. They have also a system for identifying bomb-carrying satellites?"

"No, Mr. Chairman, that project was cancelled. They funded the anti-satellite weapons, but dropped the satellite inspection program which would have identified the targets."

"Incredible. What has this folly cost them?"

"The American secretary says, Mr. Chairman, that the two anti-satellite systems have cost only $80 million and that both are operational."

"Truly, truly incredible. What a man." He eyed his defense minister speculatively.

The General continued:

"We also have reports on the U.S. nuclear programs. Fresh intelligence confirms that the Americans have been unbelievably successful in development of flightweight nuclear rockets and ramjets."

"But is it not true that they have cancelled their projects for a reactor-in-flight-test and for a nuclear supersonic low-altitude ramjet missile?"

"Quite true, Mr. Chairman. The latter decision in particular relieved a tremendous drain on our defense budget. We have cancelled our multibillion-ruble defensive program against the low-altitude ramjet. I am happy to report that the *SLAM* team in Texas has been broken up and assigned to other projects."

"TELL ME, GENERAL, speaking of budgets, how was it that I was not briefed on some of these projects such as the over-horizon radar and anti-satellite systems when the American budget was presented to their Congress?"

"These did not show in the budget, Mr. Chairman. These and many others such as the A-11 and SR-71 aircraft projects. They were concealed funds, similar to the vast CIA concealed funds."

"Ah," said the chairman, "how much easier it is under the capitalist system. Sometimes I think there are advantages to a democracy. In regard to budgets, I understand the American Administration is bragging about the vast increase in military strength brought about by the first Kennedy-McNamara budget in 1961."

"Yes, Mr. Chairman. That is the one in which they cancelled two *Titan* squadrons, cancelled the *Snark* missile program, cancelled the *Eagle* missile program, cancelled the nuclear propulsion aircraft program, cancelled plans to put the *Polaris* missile aboard the cruiser Long Beach and cancelled plans for a large military space program."

"Incredible. Tell me, what is the miltary pilot Goldwater saying he will do about this if he takes office?"

"He says he will build more airplanes."

"Airplanes, in this age when we already are deploying antiaircraft missile systems around Leningrad and Moscow and when we are building our fantastic new space ships? Airplanes? Incredible. Absolutely incredible. I suggest, General, that you proceed with your briefing on China. I will never understand these inscrutable Americans."

William J. Coughlin

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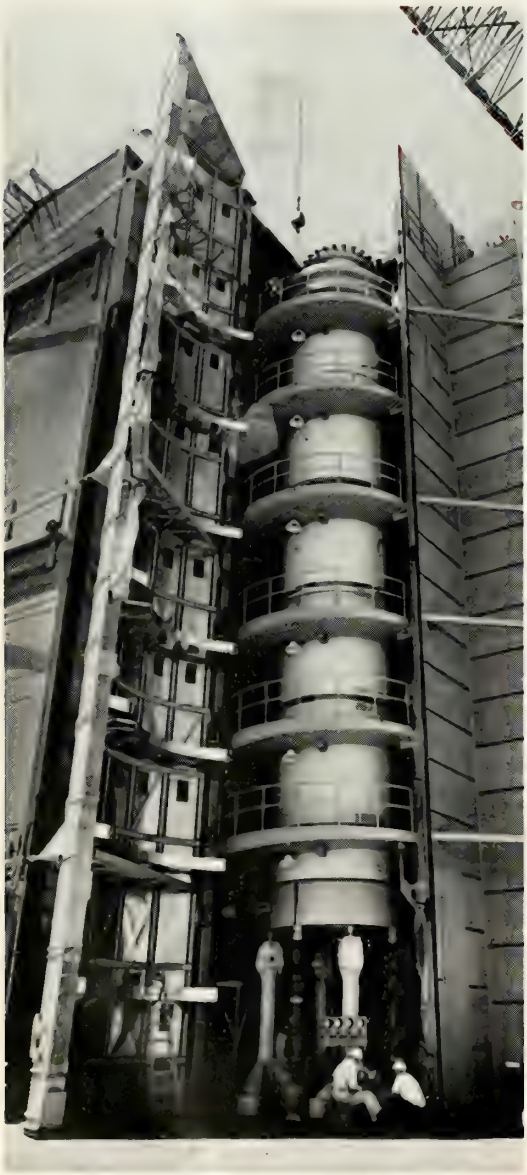
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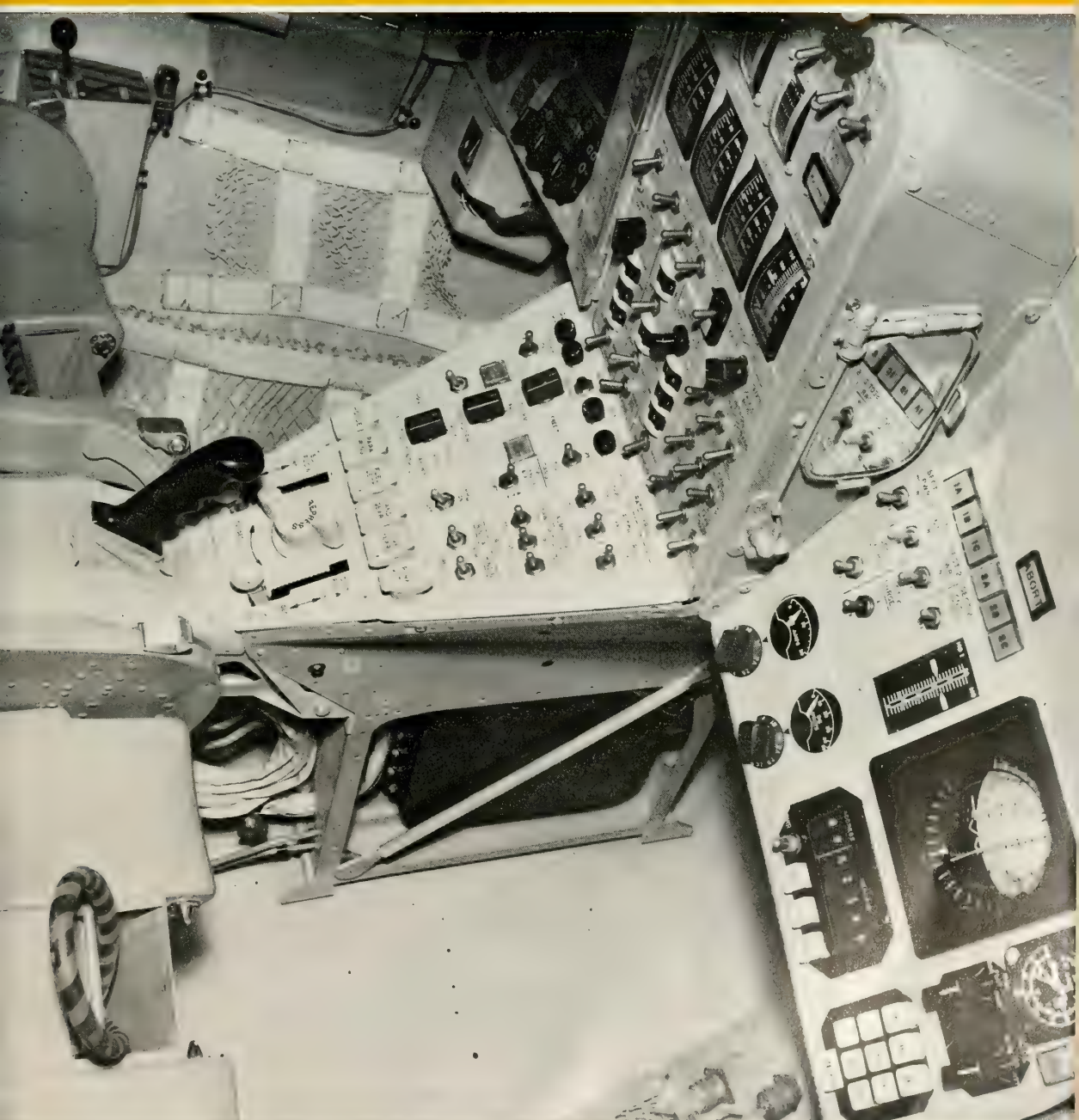


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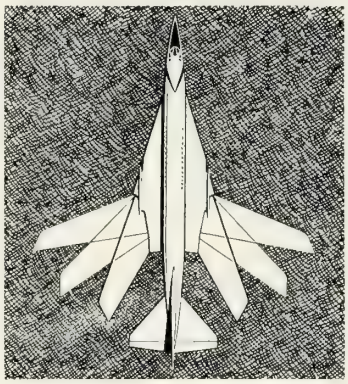
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or advanced degree required in applied mechanics with significant aerodynamic and structures background related to high-speed aircraft. Should be familiar with latest theories and techniques for analysis and test.

Stability and Control—Openings require strong background in airplane flight control system design and analysis, and stability and control characteristics, plus knowledge of computers, servomechanism design and development and testing of airplane configurations. Master's degree or equivalent.

Flight Control Systems—Positions involve establishing dynamic design criteria and specifications for flight control systems, subsystems and components; selection of most suitable control system components, and guidance of control system procurement and flight test. Requires B.S. or M.S. in engineering, mathematics or physics with applicable experience.

Metallurgy and Mechanical Engineering—Assignments entail alloy selection and application, development and improvement of processes, preparation of specifications, laboratory experiments, technical consultation, and service failure analysis. Requirements, in addition to experience in aircraft technology or a related field, include familiarity with the electron microprobe and microscope and standard metallurgical equipment.

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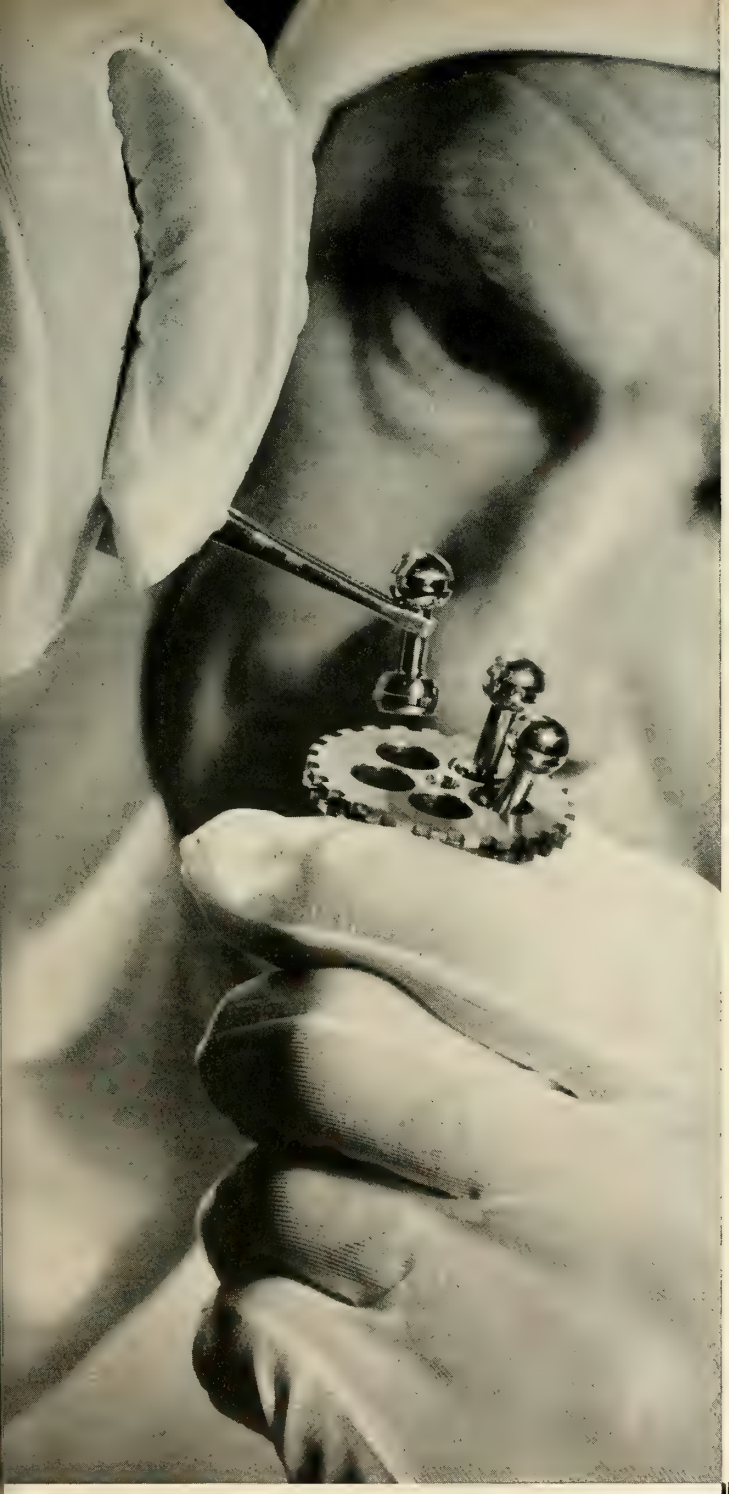
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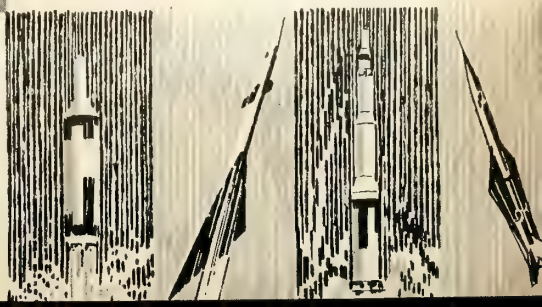
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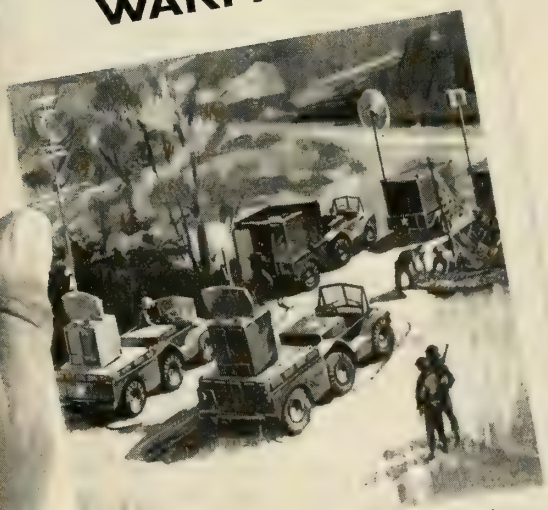
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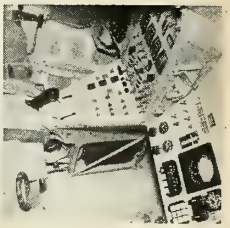
Printed at Judd & Detweiler, Inc., Washington, D.C. Second class postage paid at Washington, D.C.

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THE COVER



Gemini spacecraft cockpit shows increasing trend toward complexity of manned spacecraft display systems. Readout maze includes three-axis attitude position, velocity, acceleration, fuel management and time indicators, plus guidance computer outputs. M/R's special report on advanced display systems begins on p. 27.

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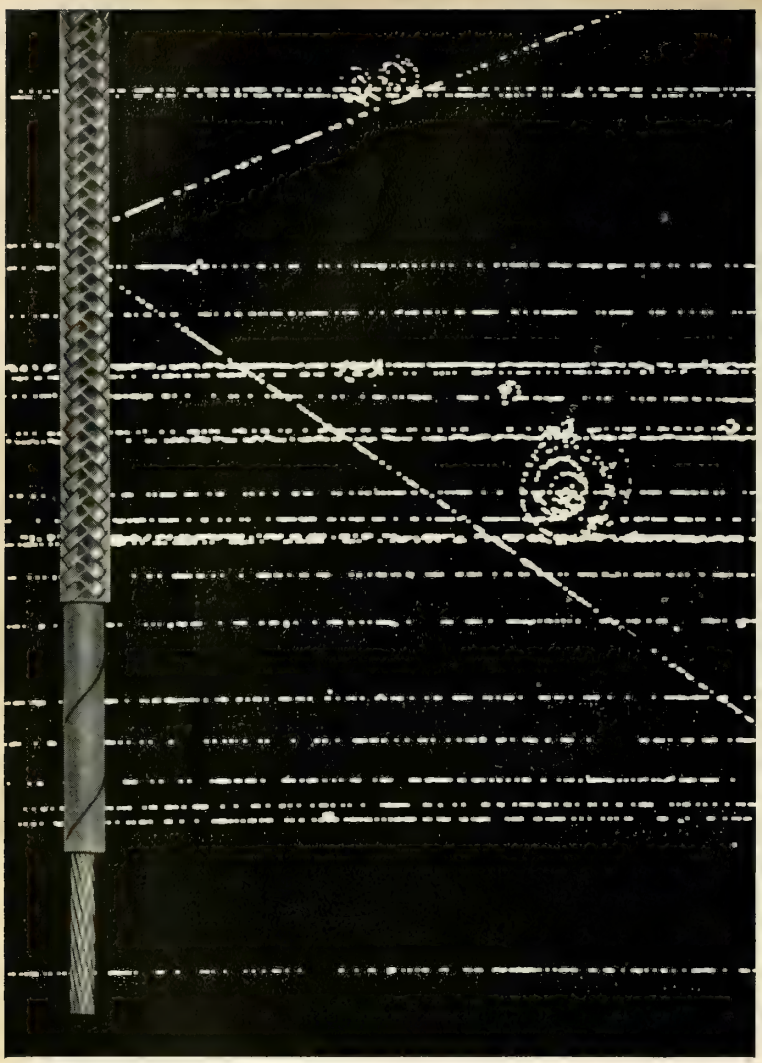
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letters

Special Report on ASW

To the Editor:

Your Sept. 1 Special Report on ASW is the most complete and technically accurate coverage I have ever seen in an unclassified publication. Well done!

W. R. Anderson
Washington Representative
Texas Instruments Inc.
Washington, D.C.

Kicking Up Moon Dust

To the Editor:

On the problem of obtaining more information on the nature of the surface of the Moon, a small explosive charge might tell a useful story.

It might be practical to have a small auxiliary rocket, with an explosive head, carried on a future vehicle such as the recent *Ranger VII*. Sometime after the beginning of picture transmission the rocket would be sent off directly ahead in the line of main vehicle flight. On impact the rocket head would explode within the field of view being transmitted.

From calculated impact velocity, and known (closely controlled) characteristics of the explosive charge, and from transmitted pictures of the rocket approach, explosion effects, and resulting pit it should, it seems to me, be possible to deduce a large amount of information.

J. J. Maxwell
Fort Saskatchewan, Alta.
Canada

'The Briefing'

To the Editor:

The Sept. 28 editorial, "The Briefing," is grand artistry. The subject is superb—but the writing is superber.

W. D. McBride
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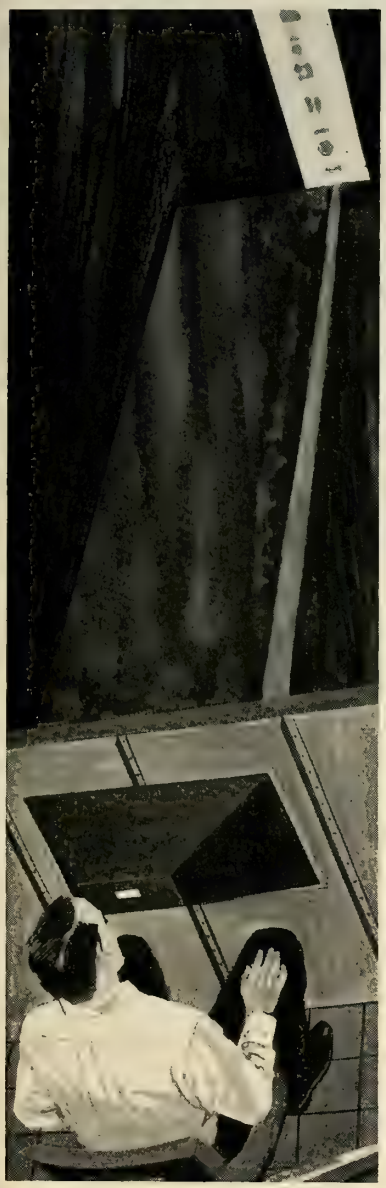
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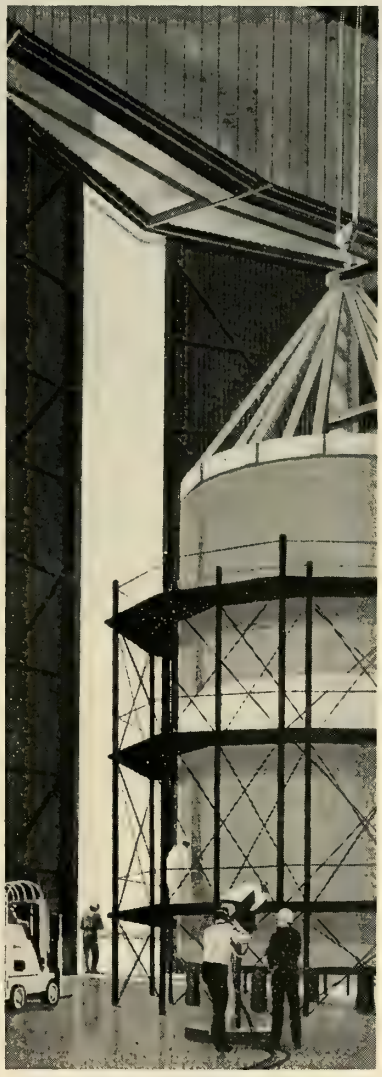
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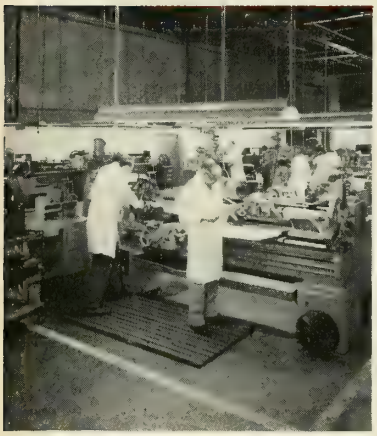
THE GIANT SATURN S-IVB is being structurally checked out in the Douglas Structures Laboratory, one of the eleven buildings in the new Douglas Space Systems Center in Huntington Beach, California. The huge building has a 90-foot ceiling and five concrete test pads, each of which is 10 feet thick and can bear an 8 million pound load. It has a unique central control system and can conduct complex test programs while others are being prepared.

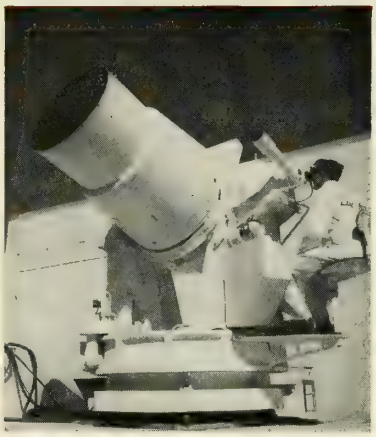


TESTING OF SATURN S-IV upper stage of the National Aeronautics and Space Administration's *Saturn* takes place in Douglas' Sacramento facility. Advanced check-out methods aided the recent successful orbiting of the heaviest satellite ever launched...19 tons comprised of S-IV and its payload.

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Land-Air Division specializes in data collection, range instrumentation and systems integration . . . it is well qualified by reason of having done so continuously for fifteen years at White Sands Missile Range and Holloman Air Force Base. ¶ The extensive experience of its personnel includes installation, operation and maintenance of range instruments, communications and telemetry systems, research and development laboratories, launch support facilities, technical supply services, logistics and inventory control . . . plus all the rest that is necessary to qualify for the use of the word "complete." ¶ With the other Dynalectron divisions —*Instrument and Electronics* and *Paradyn* —it presents in every real sense an unsurpassed capability for "systems management development" in total range operations.

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The Countdown

WASHINGTON

Next Centaur Late This Month

The fourth *Centaur* launch is now scheduled for the fourth week in October at Cape Kennedy. It will be preceded by a *Beacon Explorer* satellite launch with the *Scout* booster at Vandenberg AFB.

MOL Sea Surveillance Studied

One of the uses of the *Manned Orbiting Laboratory (MOL)* now under study is ocean surveillance. A man or men aboard an *MOL* could reject the large amount of superfluous data—relating to normal ocean traffic—that would be collected by an unmanned system, and concentrate on Soviet submarines. Space planners see this as a particularly useful application of the spacecraft.

Hercules Sites To Increase

Number of on-site *Nike-Hercules* antiaircraft batteries is expected to increase to 54 by April, 1965, Gen. Harold K. Johnson told the National Guard conference last week. At present there are 46 batteries manned by about 7,000 Guardsmen.

Army Considering New Missile System . . .

A new, multi-purpose, rapid-fire missile system is under study by the Army for its Infantry Advanced Reconniassance and Fighting Vehicle of the 1970's—and also as secondary armament on the Main Battle Tank. Northrop Corp's Nortronics Div. has received a $98,036 contract for the first phase of a three-phase analytical investigation of the system. Army's Development Command is managing the contract.

. . . And Navy Envisions Whole Families

Rear Adm. John E. Clark, commander of Pacific Missile Range, told the Sixth Liquid Propulsion Symposium in Los Angeles recently that the Navy will require new air-to-ground anti-radar missiles with ranges greater than enemy surface-to-air missiles. These, he said, will require throttleability, on-off restart, and high maneuverability on command, as well as long-duration thrust from a volume- and weight-limited envelope. Clark, describing the role of missiles in naval warfare for the 1968-72 era, said the Navy also will need a new family of surface-launched air defense missiles.

MSC Bolstering Chamber Structure

The space chamber at NASA's Manned Spacecraft Center is being extensively reinforced following buckling in the door section during pressurization tests in June. A 60 x 60 ft. section—including all of the door—is being removed and replaced by 1-in.-thick stainless steel.

'Tiara' May Spot Guerrillas at Night

NOTS China Lake has developed a chemo-luminescent material that may solve the critical problem of locating enemy guerrillas in darkness. Navy calls the substance "Tiara," but will not reveal its chemical composition. A pilot quantity is being produced by E. I. Dupont de Nemours. NOTS says Tiara glows brightly when in contact with oxygen but dims and disappears after a while. When mixed with wax the upper surface decays and darkens, but can be brushed off to activate lower layers. In counterinsurgency use it would be sprayed over grass and scrub and anyone walking over it would activate a brilliantly luminous trail.

INDUSTRY

Another 156-in. Shot Contemplated

Lockheed Propulsion Co.'s highly successful second firing of a 156-in. solid on Sept. 30 (see p. 11) concluded that firm's share of the 156-in. program. However, LPC has proposed, and the Air Force is considering, using the same case in another firing to test the feasibility of a 156-in.-dia. *Titan III* strap-on. This would employ the same liquid thrust-vector-control system being used on the 120-in. strap-ons.

LMSC Begins MOL Mock-up . . .

An engineering mock-up of the *Manned Orbiting Laboratory* has been started by Lockheed Missiles & Space Co. as part of a new, $3-million bioastronautics laboratory. To conform as closely as possible to the projected *MOL* configuration, the installation will enable astronauts to fly simulated military missions to test their capabilities in comparison with those of instruments.

. . . And Wins LORL Space Station Study

LMSC also has received a $299,000 contract from Manned Spacecraft Center for design and engineering studies of space stations ranging from single-module and multi-module concepts based on the *Extended Apollo* to the large three-radial-arm design capable of holding 18-36 men. The firm, under a nine-month contract, will incorporate all previous systems and operations concepts for building, developing, launching and operating a *Large Orbital Research Laboratory*.

GE Delivers Quickie Re-entry Vehicle

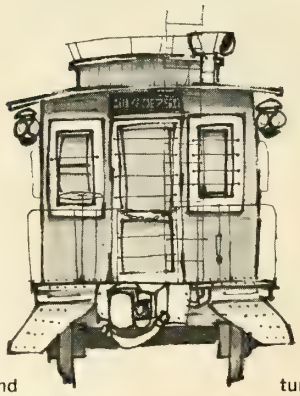
A *Re-entry Measurement Vehicle* for a classified Western Test Range program has been developed and delivered to the Air Force in what is believed to be record time. Just 16 weeks after development began on June 1, GE's Re-entry Systems Dept. turned the vehicle over to the Air Force. To be launched by an *Atlas* ICBM at Vandenberg AFB, it is designed to collect data during re-entry into the atmosphere.

INTERNATIONAL

NASA Opens Shop in Paris

The space agency has established an office in Paris to maintain liaison with the various regional and national space programs in Europe. First director of the office will be Gilbert W. Ousley, formerly with the Office of International Programs at Goddard Space Flight Center.

OUR ENGINEERS NEVER RIDE THE CABOOSE



Sometimes an engineer can get so sidetracked in the course of a project that he forgets where it was going in the first place. This is calamitous. The engineer loses interest, and the wheels start to slow down in a dozen different places. / Hamilton Standard follows the project management concept, which enables the engineer to keep sight of the entire program, providing the "what and when" direction, establishing and maintaining responsibility for the "how" and excellence of work required to accomplish the programs. Specifically, the engineer will have the opportunity to participate in and pursue a program from the beginning to final production, including phases of / 1) Precontract — prepare R&D proposals, defining the tasks, technical as well as costs and schedules. 2) Planning — developing complete detailed plans covering each element of the contract. 3) Design & Analysis — creating the hardware ideas — applying the state-of-the-art, and assuming responsibility for the basic structure of the final product. 4) Development & Qualification — preparing development and qualification test programs to determine and demonstrate product performance, conducting these tests, evaluating results, solving the problem areas to assure complete product development and technical integrity, serve as technical consultant to manufacturing and maintain customer coordination, analyzing in-service or field product performance. / Some of the present projects involve *space and life support systems, environmental conditioning systems, v/stol propulsion systems, micro-electronics, ground support equipment, turbine and rocket engine controls, industrial valves, electron beam machines, air induction and special controls.* / Hamilton engineers are encouraged to broaden their personal capabilities by taking advantage of in-plant technical courses lectures and seminars. Enrollment in useful short courses at various colleges and universities is also authorized. Engineers may also qualify for the company's rotational program. This provides opportunities for assignments in several departments to broaden the individual's knowledge of the company's scope of operations. / In summary: an engineer's future with Hamilton Standard is limited only by his ability and desire to make a contribution to the team effort — and his capacity to shoulder responsibility. He's got a wide-open track to personal progress. / *We invite you to climb aboard for an immediate interview and to submit a resume of your qualifications to this equal opportunity employer. Write to Mr. A. J. Fehlber, Supervisor of Professional & Scientific Recruiting, Windsor Locks, Connecticut.* ***Department F***

Hamilton Standard DIVISION OF **United Aircraft**

Army Awards Nike-X Contract

One of the largest single contracts ever awarded by the Army has been let to Western Electric Co. for continued development and testing of the *Nike-X* anti-missile missile system. The cost-plus-incentive-fee contract totaled $309,664,200 and covers *Nike-X* work from October 1, 1964, to September 30, 1965. Western Electric is the prime contractor for the *Nike-X* system.

The pact covers work being performed at White Sands Missile Range, N.M., Kwajalein Island in the Pacific and other smaller test sites including Ascension Island in the Atlantic.

In addition to Bell Telephone Laboratories in Whippany, N.J., which is responsible for the design and development of the system, major contractors sharing in the award include: Martin Co.'s Orlando Div., the *Sprint* Missile; Raytheon Co., Missile Site Radar and Multi-function Array Radar; Remington Rand Univac Div., Data Processing equipment; Douglas Aircraft Co., *Zeus* missile; General Electric Syracuse, radar techniques and signal processing equipment; and Avco Corp., discrimination techniques and studies.

YF-12A Shown

Advanced Hughes missile and fire control systems are expected to give the Air Force's new Lockheed YF-12A (originally known as the A-11) aircraft unprecedented attack ability against supersonic bombers and a new independence of ground control facilities.

The *AIM-47A* missile and the ASG-18 fire control system, together with the aircraft, were publicly shown for the first time at Edwards AFB, Calif., on Sept. 30. Joint tests of the three are being conducted at the Pacific Missile Range.

AIM-47A and the ASG-18 (an outgrowth of the old F-108 program) use pulsed-Doppler radar and infrared search and tracking. Air Force officials say the long-range missile has freed aircraft designers from the need to provide a high degree of maneuverability. The plane and its missile system can make a second attack run on a bomber in about one-fourth of the time required by current aircraft-missile systems.

Missiles, which can be conventional or nuclear-tipped, are carried in a bay in the YF-12A's belly, which apparently can carry at least eight. They are ejected downward by a fire control officer seated to the rear of the pilot, and are capable of Mach 6 speed after launch at Mach 3.

Shots of the Week

Minuteman II passed its first test Sept. 24 when it was successfully launched from a Cape Kennedy silo on a 5,000-mi. flight (see story, p. 17).

- The Army-Marine Corps *Redeye* man-transportable antiaircraft missile was tested Sept. 24 at China Lake, Calif. In four launchings against remotely controlled craft, *Redeye* destroyed a helicopter and a small winged target drone, barely missed a jet airplane and misfired once. (See page 16.)
- The Soviet Union on Sept. 24 launched the *Cosmos 46* satellite.
- University of Michigan engineers successfully fired an *Arcas* weather rocket from the Keweenaw Peninsula Sept. 24.
- The first four-stage launch of the *Athena* test rocket Sept. 28 from Green River, Utah, was termed a partial success by the Air Force despite an in-flight abort caused by an apparent malfunction. A computer cancelled ignition of the missile's third stage after it sensed an inverter malfunction.
- NASA's *X-15* rocket plane was flown twice last week from Vandenberg, AFB, Calif., on the 28th and again on the 30th. First was to test a new coating designed to reduce air friction heating; second was a checkout flight.
- The last shot from Cape Kennedy in the *Minuteman I* series failed Sept. 29 when the missile veered off course and had to be destroyed 165 sec. after launch. The missile compiled a record from the Cape of 38 successes, 8 partial successes and 8 failures. From Vandenberg AFB, Calif., the record was 60 successes, four partials and two failures.

DOD Offering Handbook

The Department of Defense is offering copies of a handbook designed to aid contractors in determining the information needs of scientific and technical personnel.

The handbook, which can be obtained without charge from the Defense Documentation Center by defense contractors, is the same used in a survey being conducted by DOD to aid in establishing its own information needs.

W. M. Carlson, Director of Technical Information, DDR&E, is directing the survey in selected government R&D laboratories, to determine what kinds of information are used, the form in which it is used, where it is obtained, and the types of decisions that are made with it. These conclusions will be used as a basis for an evaluation of the DOD system to see if technical information is being disseminated in the most useful fashion.

New LPC 156-in. Test Succeeds

POTRERO, CALIF.—The Air Force is preparing to test-fire a 3-million-lb.-thrust 156-in. solid motor in December "with renewed confidence" following successful test of the largest solid to date at Lockheed Propulsion Co. here last week.

The LPC 156-in. static test on Sept. 30 reached about 1.2 million lbs. of thrust, as expected, with a burn time of about 2 mins. 35 secs., 20 secs. more than anticipated. It was rated "successful in all respects" by Space Systems Div. officials on the basis of early data.

It was the second firing of the same 156-in. segment case which had been reloaded following its first firing on May 28 (M/R, June 8, p. 25). Both Lockheed firings involved a single-segment motor, which is manufactured in three sections. All three pieces contain propellant.

About 650,000 lbs. of propellant was loaded into the case for the second firing—30% more than the May 28 test. The second firing was of particular significance, AF spokesmen told MISSILES AND ROCKETS, because it proved out a new nozzle concept that will be used on the two-segment 156-in., 3-million-lb.-thrust motor to be fired at Thiokol Chemical Corp.'s Brunswick, Ga., facility in December. The latest LPC test showed "that we can get rid of the graphite now and use graphite tape—meaning that essentially we can go to a plastic nozzle," a spokesman told M/R. Rohr Aircraft Co. is now fabricating the nozzle for the December firing—a scaled-up version of the nozzle used on the LPC motor last week.

As a result of success in the 156-in. program to date, the Air Force

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DESIGN INTEGRATION

Conduct preliminary design integration studies including interface compatability, logic, information flow and power distribution. Conduct preliminary vehicle sizing with a working knowledge of trajectory analyses, propulsion performance and component design.

VIBRATION AND FLUTTER

Conduct vibration and flutter analyses of advanced tactical missile configurations. Develop advanced analytical techniques for determining vibration and flutter characteristics.

PROPULSION

Originate and conduct analyses of advanced tactical missile propulsion system including solid, liquid and hybrid rocket engines and air breathing systems. Investigate new propulsion concepts and determine applications for advanced tactical missiles.

GROUND SYSTEMS

Formulation of requirements and preliminary system design of automatic and semi-automatic electronic checkout equipment for missile and ground systems. Determine requirements for missile handling and service equipment including mechanical, electromechanical, electrical, and fluid systems.

ORDNANCE

Perform analysis, preliminary design and integration of warheads and conceptual mechanizations for fuzing systems for nonnuclear and nuclear warhead systems.

FLIGHT MECHANICS

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can be expected to push for development of some applications that have been under study for some time, including use of 156-in. strap-ons to upgrade *Titan III* perfomance, use of the 156-in.-motor clustered or strapped onto other existing boosters for space missions, use for an unlimited-range ballistic missile, and creation of an advanced *Titan-III* configuration by strapping 120-in. solids onto a 156-in. solid carrying the *Titan* Transtage.

Most immediate application, according to some AF spokesmen, would be upgrading of *Titan III* to provide the booster for the *Manned Orbiting Laboratory (MOL)*, should it become operational.

Martin Gets Pershing Award

Army Missile Command awarded two cost-plus-incentive-fee contracts totaling more than $24 million to Martin Co.'s Orlando (Fla.) Div. for engineering and R&D services on the *Pershing* weapons system.

The $23,188,823 contract covers modifications and improvements on system design, production methods, previously delivered hardware, quality control and updated manuals. The second contract for $987,893 covers R&D services.

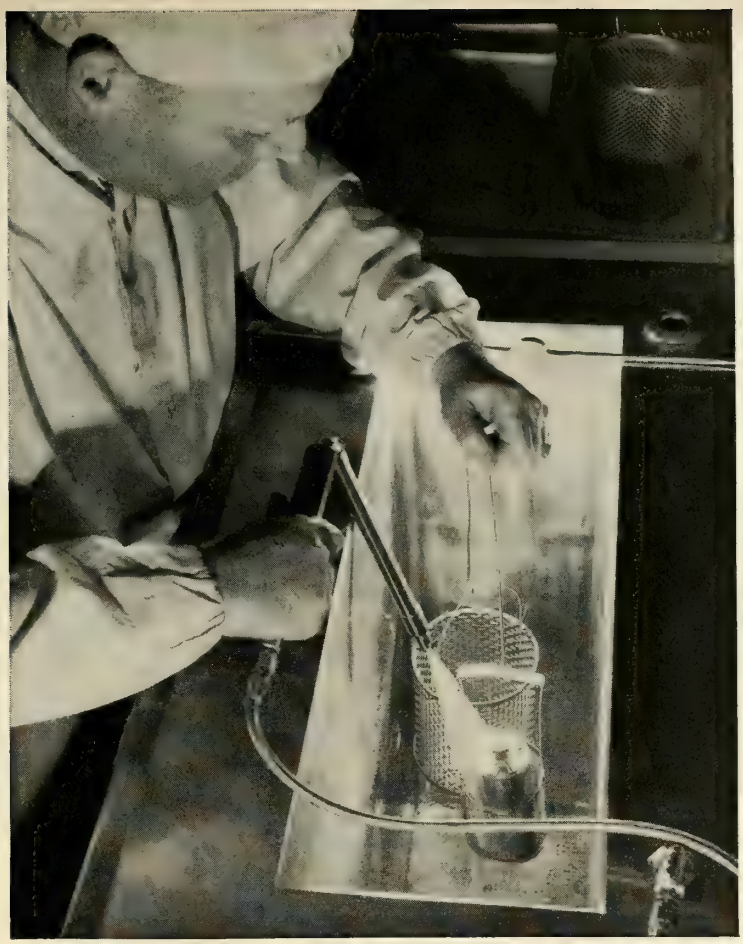
Filament Study Awarded

NASA is granting funds to Spindletop Research Center in Lexington, Ky., to pursue a new idea in fabricating boron carbide monofilaments. The study objectives include determining feasibility of the new process and a means by which the process can be varied to produce the most desirable properties. The monofilaments cannot be made by present manufacturing methods.

NERVA Reactor Fired

The Westinghouse *NERVA* reactor reached 85% of full power in a 6-minute-plus run at the Nuclear Reactor Development Station, Jackass Flats, Nev., Sept. 24. The reactor under test, NRX-A2, was designed and built by Westinghouse Astronuclear Laboratory.

The duration of the successful run was limited by the amount of hydrogen gas available for turbine drive and reactor cool-down. The reactor was operated as planned for more than 6 minutes above 56% full power by the *NERVA* industrial team of Westinghouse and Aerojet-General Corp. The first NRX test was confined to cold flow and a third is set for next spring.



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In non-destructive field . . .

DOD Weighs New War Concept

by James Trainor

THE TRULY REVOLUTIONARY potential of non-destructive warfare—a direction in which the Defense Department has never turned before—promises to have as profound an impact on military operations as the introduction of atomic weapons or Napoleon's introduction of the concept of total war. And it may be just as hard to handle—both politically and militarily.

The latter considerations, plus the difficult development problems involved, temper but do not dispel, the enthusiasm of Directorate of Defense Research and Engineering (DDR&E) officials. In non-destructive warfare techniques they see the promise that the U.S. will be able to accomplish the classical purpose of war—destruction of the enemy's will to fight—without a concomitant loss of life or material.

This nascent field is based on the use of temporarily incapacitating chemical or biological agents against primarily battlefield targets.

"The goal is to make a man militarily useless," Dr. Chalmers W. Sherwin, DDR&E Deputy Director for Research and Technology, told MISSILES AND ROCKETS, "in a controlled manner with an agent which will act in seconds and have an effect lasting from several hours to several days." Such an agent, he said, would act in a manner similar to "a powerful anesthesia" and would "literally render an individual unconscious."

● **Specs**—Although such agents do not now exist in a militarily usable form, Albert E. Hayward, Deputy Assistant Director in Sherwin's office, outlined for M/R the properties that such a chemical should possess.

First, he said, the agent can be classed by the effect to be caused. "The goal, of course, is to render the enemy incapable of movement—that is, we would like to be able to paralyze the voluntary body functions while allowing the involuntary to function normally.

"Lesser effects, however, might be just as acceptable—for instance, temporary loss of sight or disruption of normal body functioning by inducing such things as vomiting, dysentery or various types of food poisoning."

In addition to producing these effects, Hayward said, the agent should be mass-producible, stable in storage and delivery and effective at low doses. Unlike lethal chemical agents, it should not be persistent in its effects, since friendly forces would want to follow up quickly the incapacitation of an enemy force.

Since absorption is "technically hard," both Hayward and Sherwin felt that inhalation of a gas or aerosol or penetration of the skin by a hypodermic dart were the most feasible means of incapacitation.

"A good example of a temporary incapacitating agent, although it is not too useful on the battlefield, is the riot control agent, CS," Hayward pointed out.

● **Background**—Research into non-destructive, incapacitating agents began in the late 1950's. At first, the emphasis was placed on the hallucinogens (or psychotomimetic) drugs, which are basically consciousness-altering substances. Chief among these the mescaline, which comes from peyote cactus; psilocybin and psilocin, derived from mushrooms; and LSD-25 (d-Lysergic Acid Diethylamide), from an ergot of rye or wheat.

Development of these agents was, however, de-emphasized after it was discovered that the hallucinatory effects produced were not predictable and, as such, could have untoward consequences on the rational, decision-making processes of an enemy—an important consideration in an era of nuclear weapons.

Stress is now on the exploratory development of anesthetic agents in quantities suitable for tests on animals as well as research on pharmacology and toxicology. The Army Chemical Center at Edgewood Arsenal, Md., is developing the chemical agents while Fort Detrick, Md., is pursuing biological agents. Funding for the total chemical and biological program including defensive efforts is $125 million; incapacitating agents are receiving a small percentage of this total.

● **Need is people**—However, Sherwin emphasizes, funding is not the major problem. "We have been so wrapped up in electronics and space for the past several years," he points out, "that we are having trouble finding people capable of working on this problem. Our base is just not adequate for this job. What we require is not a large industrial productive effort but research and development in such areas as physiology, toxicology, and microbiology.

"We need a balanced group of people across the full spectrum of medical and biological fields and, in this, we are competing for the same people who are working, for example, on cancer research. Biologists who used to find it difficult to get a $5,000 grant are now being showered with funds as a result of the $1-billion National Institutes of Health programs and NASA's space biology programs."

On the positive side, Hayward points out that many of the large chemical companies have freely entered into agreements with DOD to make available gram-size quantities of substances which they feel might be of value to the defense program. "In this, we are extremely fortunate," Hayward says, "since these companies have the finest pharmacology and toxicology laboratories in the country." A large number of other companies—including Dupont, FMC, Stanford Research Institute and Arthur D. Little, Inc.—are also contributing to the program. An indication is the fact that 65% of the funds in the chemical and biological field are allocated to industry.

● **Within decade?**—Both Hayward and Sherwin are reluctant to place a timetable on the development of these agents, since the entire effort hinges on evolvement of suitable incapacitating drugs. Sherwin did venture a guess, however, that if developments were favorable the agents could be available within five years and very likely before ten.

Development, however, is only the beginning. Political acceptance of this type of warfare must be established and military tactics for its employment devised. Using the analogy of the development of the atomic bomb, Sherwin feels that these efforts will not be faced squarely until science has developed and handed over to the military the incapacitating weapon.

Two potential uses for incapacitating agents foreseen by these DDR&E officials are in "big country-vs.-little country" conflicts, such as Vietnam, and United Nations peace-keeping operations such as Cyprus and the Congo. ■

Radio Astronomy Observatory Expected To Get Development Nod

by Hal Taylor

NASA ASSOCIATE ADMINISTRATOR Robert C. Seamans, Jr., is expected to approve development of the *Radio Astronomy Observatory* in a few weeks.

It is still not known, however, whether development will be performed by the Goddard Space Flight Center or by a missile/space firm.

The satellite will weigh 270 lbs. and will be launched by a *Thrust-Augmented Delta*. It will have four 750-ft. antennas.

The satellite is designed to trace the location of mysterious radio emissions in space. The 750-ft. antennas form two V's extending from the spacecraft, which will permit NASA scientists to determine the source of radio emissions within an area of approximately 29 or 30 degrees of the sky.

Dr. Nancy G. Roman, chief of astronomy at NASA headquarters, says design studies for this satellite have been "pretty well completed."

"It is not yet an approved program, but we have it in our budget for this year and we expect to get started fairly soon," she added.

● **In jeopardy earlier**—Earlier in the current fiscal year, it was known that the *RAO* was in danger of being delayed until FY'66 because of Congressional cuts in the FY'65 budget.

It now appears, however, that there will be about $1 million available to get it started. The first launch will probably be scheduled for 1967.

The decision as to whether it will be built by industry or the Goddard Space Flight Center is part of the program approval document being prepared for Dr. Seamans by officials of the Office of Space Science & Applications.

The decision will be left to Seamans, who will have to weigh the current workload of Goddard engineers and facilities. Although Goddard has designed and developed many satellites, many of the heavy observatory satellites it manages have been built by industry. Another apparent reason for expecting the development to go to industry is that the 750-ft. antennas are too big for Goddard's present facilities.

● **Orbiting telescope studied**—Dr. Roman also revealed that NASA is considering a manned orbiting telescope in space in 15 to 20 years.

She said that the Langley Research Center issued a request for proposals for engineering studies of how such a telescope could be connected to a space station and how the instrument could be built so that man would be able to maintain it.

The man in the system would not be used to look through the telescope—which may be as big as 100 in. or more—but there are other useful jobs for him.

Because the telescope may be so large, the man will probably make precise adjustments in the different fraction-limited optics. Since such a telescope is also intrinsically versatile, the man would also be used to change the auxiliary instrumentation at the focus. He could also collect film and make repairs.

● **Anticipating requirements**—Although officials conceived the telescope in connection with a space station, Dr. Roman said this is not yet certain.

The telescope may be placed in orbit with a rendezvous with a manned vehicle from time to time, or it may be mounted on a space station with some isolation so that vibrations caused by men moving around will not reach the instrument.

The space agency has also asked astronomers to submit proposals for studies to determine what missions the telescope might have in the solar and stellar areas, what instrumentation and what design features will be needed to solve these problems, and what technological developments must be started now to put a telescope in orbit 15 to 20 years from now.

The proposals are due in December. NASA officials then plan to hold a symposium in about a year, at which time the results of the astronomer and Langley studies will be known. A workshop session will be held in which the space agency hopes to define in detail the technological development that must be initiated. ■

Navsat Study Group Established

SIX GOVERNMENT AGENCIES have formed a committee to determine if a navigation satellite system is needed.

The Joint Navigation Satellite Committee will be composed of representatives of the Departments of Commerce, Defense, Interior, Treasury, the Federal Aviation Agency and the National Aeronautics and Space Administration.

The committee will evaluate requirements for improved navigation, traffic control and search and rescue services. It will then determine whether a satellite system will meet these requirements and what its cost would be compared to other methods for satisfying the same set of requirements.

If a decision is reached that such a system is required, NASA will undertake research and development of the satellite.

The space agency has completed three basic mission feasibility studies—two by Westinghouse Electric Corp. and one by the Univac Div. of Sperry Rand. The University of Michigan, under contract to the FAA, conducted a study for improved over-ocean air traffic control using satellites.

The committee will review those studies as well as some funded by industry.

Members of the *ad hoc* committee are Thomas L. Austin, Interior; Leonard Jaffee, NASA; David S. Johnson, Commerce; Alton B. Moody, FAA; Thomas F. Rogers, DOD; and Capt. Billy R. Ryan, Treasury.

With some exceptions . . .

DOD Tightens Rules on Employees Accepting Favors from Contractors

Effective Nov. 24 reports of incidents must be made within two days; officials stress that no specific cases were involved in change

A MORE PRECISE definition has been issued to limit acceptance by Dept. of Defense personnel of "any favor, gratuity or entertainment" from contractors.

Aimed specifically at such practices as hospitality suites, free lunches and mementos from contractors (e.g., a tie-clasp), the change modifies the DOD Directive on Standards of Conduct issued in December, 1961.

"We found over a period of time since the directive was issued and amended in '63 here, that there have been misunderstandings and misinterpretations of the meaning of this (clause covering acceptance of favors, gratuities or entertainment)," Norman S. Paul, assistant Secretary of Defense for Manpower, explained.

"We've attempted to draft this amendment in the clearest possible terms, recognizing that this is a bit of a squashy subject, and you have to allow some leeway."

● **Firm language**—Claiming that accepting gratuities may be a source of embarrassment to the Department and the personnel involved, the change in the directive categorically forbids the acceptance of any favor, gratuity or entertainment directly or indirectly "from any person, firm, corporation, or any other entity which has engaged, is engaged, or is endeavoring to engage in procurement activities or business transactions of any sort with any agency of the DOD. . . ."

The original directive left the determination to the individual concerned and called for discretion where such favors "might reasonably be interpreted as affecting" the objectivity of government personnel. It is this multiplicity of interpretations that the change is designed to eliminate, Paul said.

● **Exceptions**—Exceptions to this rule, however, have been made in circumstances where "the interests of the government may be served" by DOD personnel participation in various gatherings sponsored by industrial, technical and professional associations.

"Participation by Defense personnel," the directive now states, "is appropriate where the host is the association and not an individual contractor." Acceptance of entertainment or hospitality from private companies at such affairs, however, is specifically prohibited.

The directive further says that the interests of the government may also allow Defense personnel to participate in some limited activities sponsored by individual contractors. It cites two examples—"launching of ships or the unveiling of new weapons systems"—as legitimate instances of mutual interest to the government and private industry. Several other limited examples, such as off-shore sales meetings, are also cited as reasonable exceptions.

● **Reporting procedure**—Beyond these limited conditions, however, any DOD employee who accepts any favor, gratuity or entertainment must report the incident and the circumstances within 48 hours to the designated representative of the service secretaries or, in the case of an employee of the Office of the Secretary of Defense, to the representative of the Secretary. The change in the directive becomes effective Nov. 24.

Paul emphasized that the amendment was not the result of misconduct on the part of either DOD personnel or contractors, but simply clarification of a situation DOD felt needed clarification. Work on the change has been going on for several months, he said, but there was "no specific instance which brought this thing about." Rather, it was an accumulation of examples that had come to the attention of DOD "through one means or another" in the course of routine administration. ■



Redeye Kills Helicopter And Narrowly Misses a Jet

REDEYE, the individual soldier's air-defense missile, shown downing a helicopter (streak from right to left) in technical demonstration for NATO and press representatives. Tests, conducted at China Lake, Calif., also included firing of the General Dynamics/Pomona missile against a jet target moving at 415 knots at 1,500-ft. altitude and slant range of 12,000 ft. Although missile missed jet, Army said it passed within 3 ft. of aircraft's exhaust pipe. Improved Hughes infrared seeker, used for first time, reportedly can distinguish "up-Sun" target at least as effectively as can the human eye.

Minuteman II May Be Operational in 1965

THE SUCCESSFUL Sept. 24 flight of the first *Minuteman II* ICBM brings the system a step closer to its planned late 1965 or early 1966 operational date. Launch was from the Eastern Test Range.

First of 36 scheduled research and development flights, the test included launching the missile from its 90-ft.-deep silo to a planned impact point some 5,000 mi. down the Atlantic Missile Range.

The three-stage solid-propellant ICBM, which is expected to join *Polaris* as the backbone of the U.S. strategic retaliatory force, is capable of carrying the same size warhead as *Minuteman I* in terms of yield. Its range is more than 9,000 mi., compared to 6,700 mi. for the earlier version. *Minuteman II's* accuracy is also substantially greater than that of any other U.S. strategic missile.

● **Accent on accuracy**—This accuracy—coupled with a sophisticated penetration aids package—gives the advanced *Minuteman* not only a greater assurance of penetration to its target but also a capability against hardened targets comparable to that of the *Titan II*.

The destructive capacity of a warhead, Defense officials say, increases with the cube of the accuracy and approximately linearly with the yield. Therefore, although the *Titan II* is estimated to carry a 10-15 megaton weapon versus about one megaton for the *Minuteman II*, halving the circular error probable (CEP), between the *I* and *II* versions gives the two systems comparable capabilities against hardened targets.

Improvements in targeting capability are another major advance in the *Minuteman II*. Multiple target information can be stored in the missile guidance computer, and, if necessary, a target assignment can be changed with the simplicity of pushing a button. Also, control of the *Minuteman II* force can be exercised from mobile airborne command posts. These command posts will be capable of firing one or several of the missiles.

● **Size of force**—Two hundred *Minuteman II* missiles have been funded to date by the Defense Department—150 to be sited at the Wing VI base at Grand Forks AFB, N.D., and 50 to be located with the first *Minuteman I* wing at Malmstrom AFB, Mont.

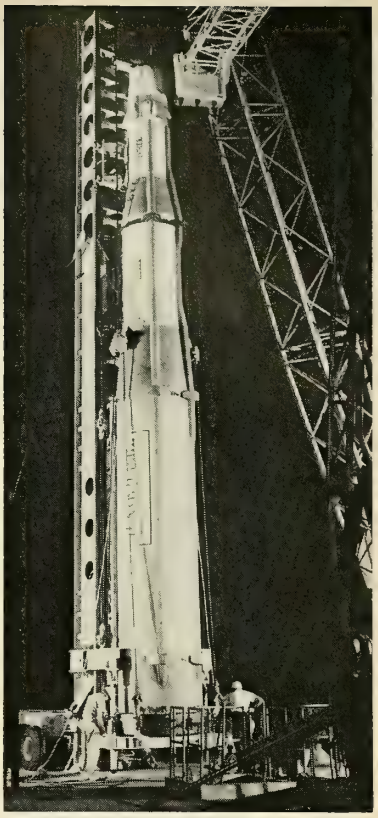
Present DOD plans are to integrate the future buys of *Minuteman II* missiles with already emplaced *Minuteman I* missiles by "internetting" the communications and control systems. This, Defense officials say, will increase the targeting effectiveness of the force as a whole. ■

Martin Gets Titan III-X RFP from Air Force SSD

SPACE SYSTEMS DIVISION of the Air Force Systems Command has issued a request for a proposal to the Denver Div., Martin Co. for "design, development, fabrication and test of *Titan III-X/Agena* launch vehicle." The request also asks Martin to provide the associated aerospace ground equipment for the program and to activate launch facilities at the Western Test Range. The program initially is to run for two years.

Thus, the *Titan III-X* has taken another step toward reality (M/R, Aug. 31, p. 11), although Air Force officials stress that the program is not yet approved for development. Officials also describe themselves as encouraged by progress in studies and informal negotiations to date and are confident the program will receive a go-ahead in the FY '66 budget.

Titan III-X is to be a nonmanrated launch vehicle for military space payloads. The basic rationale behind the program is to provide a cost/effective launch vehicle for unmanned space payloads with the same capability as the *Titan III-A*.



FIRST Minuteman II before launch.

Fluid Control System Holds MAW Potential

AN ALL-FLUID control system has been successfully fired at the Army Missile Command, Redstone Arsenal, Ala., aboard a test instrumentation missile. The system, which has no moving parts except the fluid, has potential application in the directionally controlled *Medium Anti-tank Assault Weapon (MAW)*.

Extremely simple, economical and durable, the fluid-control system performs functionally the same as an electronic package through channeling the liquid into various parts of the system. The system flown and recovered for re-use included a fluid summing amplifier, a rate sensor and a power amplifier, as well as four cold-gas reaction jets to control the missile in roll only.

The system was built by the Aeronautical Div. of Honeywell, Inc. for the Inertial Guidance and Control Laboratories of the Missile Command.

NASA Set To Launch Second Interplanetary Monitoring Platform

NASA HOPES to have two *Interplanetary Monitoring Platforms (IMP)* in orbit this week so that it can compare data on magnetic fields, cosmic rays and solar winds in space.

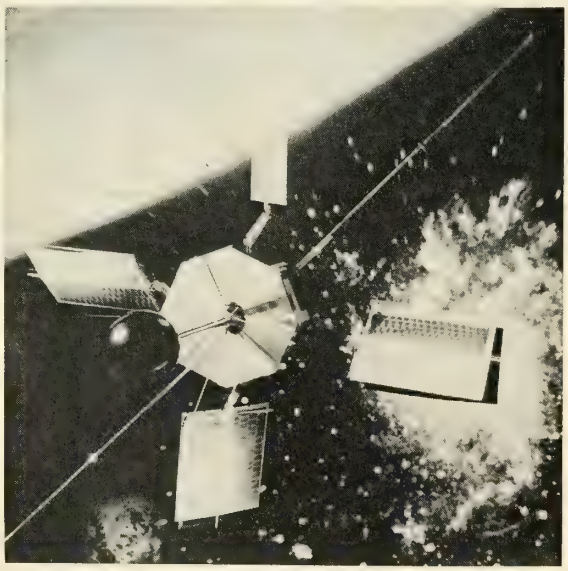
The space agency announced last week that *IMP-I* had resumed transmitting Sept. 17 after shutting down last June because of solar power loss. At the same time, the agency was preparing to launch *IMP-B*—no earlier than Oct. 2—into an orbit carrying it out 126,500 mi. into space and as close as 120 mi. to Earth.

IMP-I is orbiting the Earth with an apogee of 192,077 mi. and a perigee of 2,073 mi. Although scientists do not know how long *IMP-I* will continue to transmit, they hope it will be long enough so that data on the same space phenomena can be gathered by both satellites while at different distances from the Earth. This could provide valuable information on interrelationships of magnetic fields, cosmic rays and solar winds.

Launch vehicle for *IMP-B* is the three-stage *Delta* booster. Orbital period for the 136-lb. spacecraft was expected to be about 98½ hrs.

● **Experiment contributors**—It carries nine experiments contributed by scientists from the Universities of California and Chicago, MIT, Goddard Space Flight Center and Ames Research Center.

The satellite has an octagon-shaped base, 8 in. high and about 28 in. dia. All but two of its experiments are mounted in the base. The rubidium magnetometer is mounted on a boom that telescopes out to a distance of six feet after orbit is attained. In addition, two fluxgate magnetometer sensors—folded at launch time—are extended on booms seven feet away from the satellite in orbit.



CONCEPTION of IMP-B, second in NASA's Interplanetary Monitoring Platform series. Six of eight experiments are in base.

The satellite is spin-stabilized in orbit. Solar cell arrays are mounted on four panels and the power derived from the Sun charges 13 silver-cadmium batteries. The tiny four-watt transmitter it carries weighs only 1½ lbs., but it can transmit data back to Earth from distances of more than 126,500 mi.

● **IMP-I data detailed**—Space agency officials said that *IMP-I* has already contributed valuable new scientific information.

Perhaps the most noteworthy have been the studies of the boundary or transition region between the Earth's magnetosphere and interplanetary space. *IMP-I's* contribution has been the discovery of a shock wave preceding the Earth's magnetosphere.

This wave, similar to that created by a supersonic aircraft, is caused by the solar wind. Between the shock wave and the magnetosphere boundary, a turbulent region of highly energetic plasma also has been discovered.

Mapping of these regions by its magnetometers also shows that the shock wave and the turbulent transition region trails back and away from the Earth in increasingly widening bands, much in the manner of the wake of a ship at sea. This wake of particles, in lessening intensity, may extend as far back as a quarter of a million miles.

● **New discovery**—*IMP-I* made another important discovery Dec. 14 and 15, 1963 when it was near apogee during its fifth orbit. Its magnetometers registered significant increases in magnetic field strengths that had not previously been noted in interplanetary space. Evaluation of the data coupled with the known position of *IMP* in space has attributed the increasing magnetic field to the fact that the spacecraft was passing through the tail portion of a lunar magnetosphere.

NASA said that while these discoveries have been the most significant new finds of *IMP-I*, studies of the strength, velocity, and changes in solar wind, plus new insights into the intensity and time variations of cosmic rays have also been of more than routine scientific interest.

The *IMP* spacecraft series was designed, built and underwent environmental testing at the Goddard Space Flight Center. Prime contractor for the *Delta* launch rocket is the Douglas Aircraft Co. ■

Single Office Proposed to Combat Shortage of Scientists and Engineers

by Heather M. David

A SPECIAL Congressional committee strongly recommends that a single office be set up to marshal the nation's engineering and science manpower to meet the demands of research and development programs.

The one fact emerging from a study by the House Select Committee on Government Research is the abysmal lack of uniform data on the distribution and actual size of the supply, and of adequate methods of projecting the demand.

Growth of the space program particularly has led to various Cassandric prophesies as to shortages of professional personnel. These earlier estimates were later revised, especially as proponents of the space program sought to defend it against charges of monopolizing the country's technical talents.

Now, two recent surveys from authoritative sources again project a shortage toward the end of the present decade. Even these differ as to degree. For instance, the Engineering Manpower Commission (EMC) predicts, based on a survey of employers' estimates, that industry will require 37% more engineering and scientific personnel by 1973; government, 18% more.

However, the Bureau of Labor Statistics, which bases its predictions on theoretical analyses of the probable expenditures for R&D in the future, says that industry will increase its need by 1970 by 59%, government 42%.

While the EMC puts the total increase in demand at 34%, the Bureau of Labor Statistics estimates it at 73%. It should be noted that EMC does not include college and university employees in its survey, nor scientists other than those in the physical sciences. However, this does not account for all the differences.

What may affect the estimates of the Engineering Manpower Commission, the Select Committee pointed out, is the fact that the data for the report were collected during the fall and winter of 1963-64, during which time there was "considerable uncertainly" within industry and Government agencies about the manpower effects of proposed cutbacks in Federal defense and space spending. Trend of long-term demand "is upward if national goals are to be met," the committee was advised.

Whichever projection is accepted, the committee still feels that the shortage will be severe enough to warrant remedial action.

• **Goldplating rapped**—The committee admonished both industry and government for the practice of "stockpiling" talented personnel. In such instances, it said, a project which might be carried out by one Ph.D., two bachelors of science and six technicians "might be staffed by four Ph.D's, and four other degree-holders because the industrial or governmental employer wants them available for possible future projects." This practice actually degrades the ability of the professionals, it said, as well as creating shortages in other areas.

The committee suggested retraining older and more experienced personnel in new areas of technology as a method of meeting the demand. One paradox of the current situation is that many experienced, highly qualified personnel may now be laid off as projects are terminated, while recent graduates are readily employed.

Another source is increased use of women, both full- and part-time, the committee said. At present, only 12% of the scientific force and 1% of the engineers are women. Another factor industry and government agencies should look at, the group said, is whether sufficient staff help is being provided the professionals.

Current engineering and science enrollments will not meet the need, however cautious the prediction. These are now estimated to be producing about 31,400 new scientists each year, and 45,100 new engineers.

The Select Committee recommends that because of the divergence of opinions, a central office should be given the responsibility of coordinating all data, and making projections of trends, requirements and availability of personnel. This office should report to Congress and to the President at least semiannually. ■

Activity	Number of employed engineers Dec. 31, 1963	Projected employment increases based on 1963 employment		Number of employed physical scientists Dec. 31, 1963	Projected employment increases based on 1963 employment	
		1965	1973		1965	1973
		Percent	Percent		Percent	Percent
INDUSTRY AND GOVERNMENT	**212,782**	**5.4**	**26.2**	**42,554**	**8.9**	**33.9**
INDUSTRY	**175,444**	**4.4**	**27.9**	**35,448**	**7.4**	**37.2**
Aerospace	44,704	1.6	31.3	7,309	6.3	46.8
Chemical	11,590	2.3	21.2	6,586	6.3	27.7
Communications	10,266	6.4	34.6	49	14.3	83.7
Construction	1,522	8.2	37.0	18	55.6	261.1
Consulting services	4,444	6.3	28.7	71	16.9	56.3
Electricity and electronics	52,725	6.5	31.0	11,039	9.5	46.2
Food products	358	14.2	49.2	279	11.5	37.6
Instrument manufacturing	1,116	8.6	60.9	13	38.5	176.9
Machinery manufacturing	5,248	3.4	15.4	201	9.0	43.3
Metals—primary and fabricating	998	6.6	24.5	159	8.8	34.6
Mining—smelting	764	7.6	13.9	185	13.0	23.8
Paper products	878	21.1	64.6	137	22.6	59.1
Petroleum	9,872	3.7	16.4	5,009	2.6	12.0
Railroads	2,185	−11.2	−5.0	41	.....	7.3
Research and development	11,901	8.3	37.6	3,314	10.1	39.6
Stone, clay, and glass	1,140	7.0	35.7	239	14.2	72.8
Utilities	13,875	2.3	10.1	372	11.0	40.1
Miscellaneous	1,828	5.7	21.2	427	3.5	16.6
GOVERNMENT	**37,338**	**10.2**	**18.1**	**7,106**	**16.2**	**17.6**
Federal Government	17,172	13.4	23.0	6,742	16.5	17.1
State government	17,467	7.9	14.2	295	9.8	20.0
Local government	2,699	4.9	12.5	69	15.9	60.9

Source: "Demand for Engineers, Physical Scientists, and Technicians, 1964."

Engineering and physical sciences growth in total employment, 1962 through '73.

POT-POURRI

Published monthly by Giannini Controls Corporation to advance our belief that the truth need not be dull.

THIS MONTH:

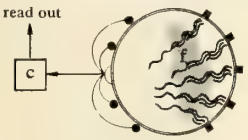
NUCLEAR MEASUREMENT OF WEIGHTLESS FUEL
WORLD'S SMALLEST PRESSURE X'DUCER
SALES GROUP DESIGNS SPACE CAPSULE
LETTERS TO THE EDITOR

WEIGHTLESS FUEL IS A PROBELEM

When a space vehicle's fuel tank goes weightless, probe-type measurement devices go non-operational. At zero-G, fuel just meanders around the tank in globules, droplets or mist. And you just can't measure an amorphous or moving mass with a fixed probe.

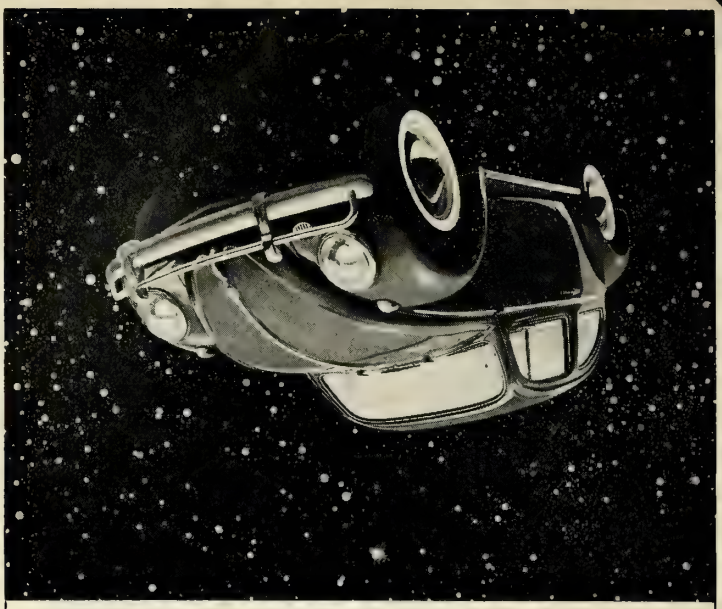
The men of our Control/Nucleonics Division, firm in their belief that there's a radiological answer for everything from dandruff to Mau-Mau, recently laid the weightless fuel problem to rest. Here's how:

The drawing below represents a cross-section of a space vehicle's fuel tank at



zero-G. The fuel (f) is a free-floating puddle inside the tank. The little squares (▪) at the right of the tank are sources emitting radiation. The dots (•) around the other side are scintillators which detect radiation levels. As the radiation (≈) from the sources passes through the fuel, it loses intensity in ratio to the fuel's mass. So, the scintillators see less radiation than the sources emit. This reduction in intensity, when fed through a miniature GCC computer (c), gives an accurate, continuous reading of fuel residuals, regardless of attitude or G-loadings. Also, note that our hardware is completely external, with no internal plumbing to get honked up. Simple, isn't it?

OK, gang. Now, how about dandruff?



DAS VIER MAN VOLKSKAPSEL, MARKE IV

Ever ask yourself how sales engineers would tackle a major design problem? Wonder no more. Above you see a space capsule. It comes from a group therapy session chaired by Tucker Benz, erstwhile GCC systems seller*.

Behold the Volkskapsel. What it lacks in concept, it gains in raw saleability. Look at that configuration. They'd love it in Huntsville. Regard the $1695 POE price (not including fuel gauge described at left). How could Congress object? As for the tax-paying public, at last they'd have a space project they could identify with. As for the Astronauts, well . . .

For a rendering of the Volkskapsel, drop us a line care of T. Benz.

LETTERS TO THE EDITOR

Dear Editor,

I object to how we name ~~our~~ space projects.

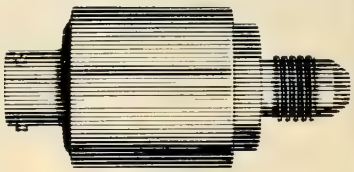
For instance I bet you don't know that Apollo came from a mixed up immorale family. Well he did and his father Zeus was a nut who went around tossing thunderbolts at anybody he didn't like and his mother Latona never even got married to Zeus and Apollo hung around a lot with satyrs and centaurs and show business people like that.

Also there was Apollos own son who got his hot rodding delinquent hands on Apollos sun chariot one day and burned up the equator and froze both poles so Zeus got mad and killed the kid with a thunderbolt. ~~and then I quit~~

If we got to name our space stuff after people like these why not use Tennessee Williams characters? At least they're Americans. Mad Taxpayer

PS I bet you don't print this.

**In reward for his great systems knowledge, Mr. Benz has been elevated to Marketing Mgr. of GCC's Instrument Division.*



CUT PRESSURE X'DUCER PAYLOADS 1/3

We've carved ½" and 2 oz. out of our miniature 1½" pressure transducers. The results are the smallest, lightest potentiometric transducers in anybody's inventory.

Stable at 75 G's

These new midgets come in both high and low pressure versions covering 0 to 3,500 psia. Weight is 3 oz. Temperature range is −65°F. to +200°F. They're stable at 50 G's vibration and acceleration (up to 75 G's for the high pressure version). Impressive? It's a small wonder!

MORE DATA *For additional information, use these reader service #s:*
Fuel gauging 10
Midget x'ducer 11

GIANNINI CONTROLS CORPORATION
1600 South Mountain Avenue, Duarte, California

Technical Countdown

MATERIALS

Apollo To Get Plastic Cover

Project *Apollo* engineers believe a plastic cover over the Command Module will save about 300 lbs. of ablative material, protect the ship during launch and prevent the escape rocket from fogging the spacecraft windows when it is jettisoned. The form-fitting cover will shroud the rendezvous and docking mechanism at the top of the cone and drape over the remainder of the module. The shroud will be tested at White Sands in November during a maximum *q* abort test aboard the *Little Joe II*. The cover will be fixed to the launch escape tower and jettisoned after first stage *Saturn* burnout. NASA officials estimate the shroud weight to be between 400 and 500 lbs. The early jettison should result in a net savings of about 300 lbs., since it will eliminate the extra ablative coating needed to handle ascent heating. As now planned, the *Apollo* will be launched as a truncated cone with the male connection of the docking mechanism exposed. This will be capped by a 1-in.-thick, rigid cone-shaped cover of glass fiber honeycomb. Behind this cap the shroud will be of flexible glass fiber construction impregnated with Teflon. A zippered opening will allow astronaut egress and all but one visual port will be covered until the jettison action.

U.S. Steel Producing Maraging Steel Sheets

Maraging steel sheets with yield strengths of 200,000 to 340,000 psi are commercially available from U.S. Steel. The steel has a one-million-to-one strength-to-weight ratio, making it ideal for many missile/space applications. U.S. Steel uses a special electric furnace air-melt process to turn out heats of maraging steel as large as 85 tons. The firm is also marketing a complete maraging steel product line including plate, bars, strip, wire tubing and rolled or forged billets. The basic compositions for the high-nickel alloy were developed by International Nickel Co., Inc.

Thermo-Lag on Centaur

Aerodynamic heating developed during the launch phases of *Centaur* rocket flights is being controlled by a shielding based on Emerson Electric's Thermo-Lag subliming coatings. The ascent insulation coating is being used on the interstage adapter that shrouds the *Centaur* engines and connects the upper stage to the *Atlas* booster. Thermo-Lag insulations are designed to sublimate at various temperatures, thus providing a measure of heat blockage to an underlying structure.

Pershing Casting Helps Save $1 Million

An electronically-programmed centrifuge machine for casting highly accurate aluminum and magnesium parts has contributed to savings of $1.14 million on the first- and second-stage *Pershing* attitude-control vanes. Designed and built by the Pomona Div., Electronic Specialty Co., the machine is capable of swinging heavy molds up to 500 rpm without vibrations or oscillations. Centrifugal castings have exceeded strengths achieved in comparable wrought parts. The device was developed under the sponsorship of the Logistics Command, Basic Industry Branch, Wright-Patterson AFB and the Norair Div. of Northrop Corp.

PROPULSION

Rocketdyne Fires Reinforced Solid

A 30-in.-dia. reinforced-grain solid rocket has passed its first test firing in a $5.5 million Air Force program at the Rocketdyne Div., North American Aviation, McGregor, Tex., plant. Reinforcement is achieved by substituting wire for the metal powder additives used in solid propellants. The wire is wound into the grain in a method similar to filament winding. Propellant grains manufactured in this manner are able to contain high pressures and can be used with extremely thin, lightweight motor cases. Several motors will be tested with a thrust vector control system. The *TVC* system will combine with a submerged nozzle assembly and an omni-axial gimballed exit cone. The reinforcing program is aimed at high-performance upper stages and air-launched propulsion systems. Funding is directed by the Air Force Rocket Propulsion Lab, Edwards AFB.

Steam Launching Perfected by Goodyear

In reduced scale tests of a launch concept at Goodyear Aerospace Corp.'s Litchfield Park, Ariz., facility, concrete missiles weighing more than a ton have been launched 200 ft. into the air by the steam produced from a single gallon of water. The launch system is based on an exothermic generator and forces water through a flow of hot particles created by the rapid burning of an exothermic material. Goodyear initiated the test sequence after developing the generator in conjunction with Dyna-Tech, Inc., Tempe, Ariz. Pressures in the 20-in. launch tube reached only 60 psi, and maximum steam temperatures ranged from 300° to 500°F in the tests. Goodyear engineers say two separate commands are needed to actuate such a system instead of the single command sequence now used.

Nuclear Brayton Cycle Proposed

Aerojet-General Nucleonics and AiResearch Corp. have completed the conceptual design study of a 100-kw nuclear electric space power system they say is capable of 10,000 hours of unattended operation. Based on the Brayton thermodynamic cycle, the system gets its power from a gas-cooled reactor that has a 760-kw thermal power with an outlet gas temperature of 1,500°F. Fuel is fully enriched uranium dioxide pellets clad in Hastelloy K tubing. The unit is being proposed to NASA and the AEC as an alternative to the Rankine cycle SNAP units.

SPACE MEDICINE

Sports Stresses Scanned for Astronauts

NASA's Manned Spacecraft Center is funding studies to assess the effects of stress on healthy athletes, with emphasis on the cardiovascular system. Athletes engaging in such sports as skiing, skydiving and sports-car racing have been monitored and tested before and after their activities. One result: A team of sports-car racers at Daytona Beach who participated in a grueling 12-hour race had cardiovascular effects comparable to that experienced by Astronaut Gordon Cooper in *MA-9*. Data procured will aid space medics in distinguishing vetween the effects of weightlessness and the effects of stress in future spaceflights.

Soviets Outline Approaches To Construction of Bases on Moon

TODAY NO ONE BELIEVES that flights to the Moon and its conquest are any longer a matter of the distant future. Recent achievements of Soviet and foreign science open continually new possibilities in the conquest of outer space and of other celestial bodies—in particular of the Moon.

The Moon is characterized by specific physical conditions entirely different from terrestrial ones. Therefore, many of the building methods used on Earth will be inapplicable on the Moon.

Future design and construction of habitable shelters on the lunar surface call for the solution of a number of problems, which can be divided into three basic groups:

Physical studies of the Moon;

Testing of building materials and structures suitable for lunar conditions; and

Development of functional means of communication in the shelters.

Study of the surface layer will decide the shape and the structural layout of lunar buildings.

The presence of natural shelters (depressions, folds, caverns), the possibility of extracting oxygen and water from lunar rocks, the presence of natural heat sources—all these factors could considerably simplify the problem of building on the Moon. It is especially important to study the physical and chemical properties of lunar rocks with the view of using them as structural material.

The builders must formulate their requirements for materials and structural elements which might conceivably be used under the specific conditions on the Moon. Vacuum, various types of radiation, the action of meteoric bodies of various sizes and velocities, and temperature fluctuations impose very strict requirements on the lunar shelters.

Elastic materials (films, membranes) well proved in "terrestrial" pneumatic construction may possibly require protection from the negative effects of the aforementioned factors. It will therefore be necessary to make special studies of stable materials on the one hand, and of special protective devices on the other.

Specialists in building materials are faced with the solution of a self-contradictory task: to design an air-supported and elastic structure which is at the same time both rigid and stable.

● **More problems**—In addition to the optimal selection of materials, it is already possible to outline certain problems connected with the building and utilization of structures on the Moon. They are:

—To provide airtightness;

—To develop technology for fabricating structures or their components;

—To develop assembly methods;

—To develop methods for adding units, changing the configuration, replacement of damaged parts, and exploitation of the structures.

In connection with the above a more general problem arises: namely, the right solution of the "man-space" interaction, which means the best and most compact utilization of space as outlined below:

—A convenient and efficient interconnection of the separate parts of the whole;

—Reducing to a minimum the space used for communication only, while providing necessary comfort and safeguarding technological requirements;

—The most economic configuration of the complex which at the same time provides the maximum of comfort for the crew.

There are many problems connected with the unusually low force of gravity, as well as the psychological effect on man of confined space, the effect of light color, the shape of the shelter, and finally, the absence of atmosphere and the danger from meteors and from ionizing radiation.

It will be necessary to study to what extent the force of gravity will affect conventional planning, taking into account the movements of man in space.

If one temporarily disregards the possibility of using lunar material and natural shelters, then the shape and size of shelters will be, first of all, limited by the weight and size of components to be transported there. Therefore, in the initial stages of Moon exploration it probably will be possible to use final stages of space rockets as living quarters.

● **Air-supported structures**—Furthermore, considering the absence of atmosphere on the Moon and the transport problems this involves, the use of air-supported structures is of some promise. The special feature of lunar buildings will be a high inner pressure which, in combination with low gravity, will create entirely new conditions for such structures.

It is obvious that the forces involved will be smallest when the shape of the structure is analogous to the evenly distributed forces. At the same time it is hard to imagine that the spherical shape (most suitable from the point of view of inner pressure) and having the least surface for the maximum

IAF Paper Reflects Growing Lunar Interest

THE PAPER translated and published on this page (in slightly condensed form) was presented at the Fifteenth Congress of the International Astronautical Federation, held in Warsaw, Poland recently (M/R, Sept. 14, p. 16; Sept. 21, p. 16).

Originally entitled "Architectural Problems as Applied to Building on the Moon," it was written by Messrs. B. V. Zayonchkovskiy, L. N. Lavrenov and B. G. Tarasevich.

Although there are no startling new concepts in the paper, M/R is publishing it because it is perhaps the first such Soviet discussion of Moon bases presented in an open conference.

At the IAF meeting, incidentally, USSR observers showed intense interest in all U.S. papers involving lunar landing and lunar bases.

volume will in all instances satisfy the whole range of problems involved—the "geometry" of gravitational forces, fabrication techniques, assembly methods, exploitation, replacement of components, adding new units, etc.

Therefore, the study of the properties of outer shells and their use in new extraterrestrial conditions is becoming a complex, but for the architect an interesting, task.

In this case, modern architectural methods and theory may play an important role.

● **Choosing shape**—One should bear in mind that assembly methods will affect the configuration of the structure and of its components. It is necessary to consider what shapes would give the simplest joints without wasting any of the usable space. It is essential to know all the design peculiarities of the given joining system.

The following must be studied: 1) the range and feasibility of expansion; 2) the geometry of components; 3) the effect of low gravitation; 4) inner changes when enlarging the strucure; 5) communication and interconnection and a number of other questions pertaining to utilization of space in "expanding objects."

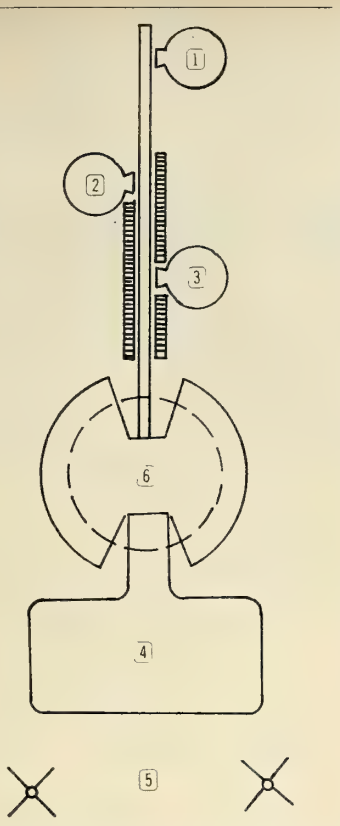
In addition, problems of air and water regeneration, the design of a closed ecological system, and problems connected with lower gravity will affect the planning and such layout of the shelters to which we are used on Earth. It will be useful to know in advance what special planning arrangements will have to be made to avoid conflicts in the various research programs.

● **Anthropometry**—Of no less importance are anthropometric studies using modern measurement and control methods. It is clear that all dimensions of shelters, subcomponents and equipment should be chosen to suit man. Under lunar conditions the use of anthropometry becomes very important, first of all, because all dimensions will have to be reduced to a minimum, and secondly, because of the change in the characteristic motions of man under unusually low gravity.

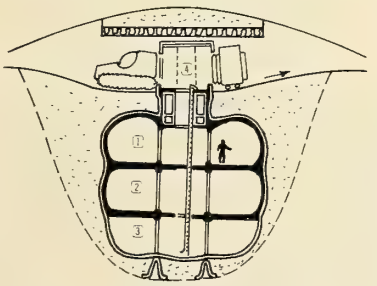
We will try to demonstrate on an arbitrary graphic example—an artist's conception (see accompanying illustrations) called "Stationary Research Station on the Moon"—how important such research is.

This sketch and any of its elements are merely a concept. It was designed especially with the purpose of illustrating the complexity of the problem and bringing up the salient points in the organization of such a project in space. The other purpose is to show that the solution of all these problems depends on the solution of the volumetric and spatial problem of such a structure.

● **Protection**—To protect the structure from meteors, the various types of radiation and temperature fluctuations, it will probably be necessary to lower it into the surface layer of the Moon. The cavity for it could be man-made (blasting techniques), or natural ones might have to be found. The structure would be protected from the top by available material, to save weight. Only communication vents would protrude from the surface.



RESEARCH Complex: 1) power unit; 2) astrophysical unit; 3) biological unit; 4) transformer platform; 5) antennas; 6) station.



CROSS-SECTION of station: 1) working level; 2) living quarters; 3) "technical" level; 4) air lock.

The station itself would consist of a pneumatic structure attached to a central hexagonal rigid member. This central element would also serve as a communication shaft, with various platforms joined by a ladder.

The elastic pneumatic structure would consist of a tough outer shell encasing the whole station, and of inner lighter shells forming the separate units.

The air in this structure will not only supply respiration but will also be a structural element. It will provide constant support from within and keep the separating and carrying elements under tension.

● **Floor plan**—Under the cover of available material will be three segments of the station, one on the top of the other. The lowest level will be the "technical" floor. It will contain air and water regenerating systems, food stores, emergency water ration, emergency air supply and emergency electric power units.

Above it will be the living quarters, consisting of a number of units of identical size. Some of them will be individual units for the crew, each two connected by emergency doors. The rest will contain a kitchen, a sanitary unit and other auxiliary installations.

Above the "living" floor is the "working" floor with laboratories and a communication center. The upper end of the shaft will contain exits and hydraulic locks (air-liquid-vacuum) which will give a minimal loss of air. On the surface will be containers with scientific apparatus, antennas and a power unit.

In the solution of the design problem the regenerating system will be of great importance. In what sequence should the air circulate through the living and working quarters? What should be the pressure at the various points? Much will depend on the solution of the problems with air in the overall design of the project. Design of safety and emergency measures will also depend on it.

The correct solution of the space problem, from the psychological point of view, will be reflected in the selection of shape and dimensions of the quarters (variety and change).

Such requirements may be in conflict with other, equally important needs; the compromise will have to be found through architectural planning.

In conclusion one should note that the problem is highly complex and can only be solved through cooperation of engineers with medical specialists, biologists, architects and construction specialists.

The achievements of science produce new problems for architecture, but its purpose remains the same. Development of architecture on Earth was and is the history of active adaptation of man to nature and its subjugation for his own purposes. ■

U.K. Program To Use Black Knights

by Frank G. McGuire

LONDON—Great Britain has announced plans for a national space program intended to place 200-lb. satellites in 300-n.mi. circular polar orbits with modified *Black Knight* launch vehicles.

Black Knight, which will be almost exactly 10 years old when its first orbital mission comes along, has been fired 17 times successfully from Woomera, Australia, with high-altitude scientific payloads.

The vehicle, to be developed for its new role by Westland Aircraft Ltd. and Bristol Siddeley, is looked upon as a cheap answer to getting experience with space hardware in coming years.

One interesting aspect of the program is that it follows generally the same time schedule for launching its first payload as does the European Launcher Development Organization (ELDO)—1967-68—but as recently as April British Minister of Aviation Julian Amery said it would be the *Blue Streak* first stage of ELDO that will open Britain's exploration and exploitation of space.

For ELDO, the United Kingdom is supplying only first-stage hardware and no upper stage or payload hardware, while in *Black Knight* it has a complete space program.

Amery apparently opted for a completely national effort, instead of settling for a secondary role in ELDO involving obsolete hardware. Many British observers are speculating that the *Black Knight* plans actually are several years old and have now been dusted off to enhance Tory prospects in the Oct. 15 general elections.

● **Vehicle details**—A three-stage vehicle, the new launcher will use two stages based on the present *Black Knight*'s liquid-propelled configuration, and a high-performance solid-fueled third stage.

The liquid propellants are hydrogen peroxide and kerosene, burned in Bristol Siddeley Gamma Mk 201 rocket engines. First-stage engines will be a cluster of eight LPR, paired off so that thrust vector control around swivelled axes is possible.

A pair of turbopumps will feed all eight engines, which the Minister says will be "derived from current *Black Knight* designs." Overall diameter of the first stage will be 78.75 in.

The second stage, using the same propellants, will be powered by two thrust chambers similar to the first stage types, and gimballed to provide TVC.

References to the new vehicle's engines being "derived from" the current *Black Knight* Mk 201 liquid propellant rocket engines is viewed as an indication that the Mk 301 LPR now being flight tested by Bristol Siddeley will be the actual powerplant.

Two launchings with the Mk 301 unit in the *Black Knight* vehicle have been successful, giving Bristol Siddeley confidence in the engine's reliability. The firm says performance has increased substantially.

The 54-in-dia. second stage will be topped by a spin-stabilized solid propellant rocket motor, a modification of the motor now used as a final stage for re-entry experiments. Both the third-stage motor and the payloads will be mounted within fairings, to be ejected during second-stage burning when the vehicle is out of the atmosphere.

● **Guidance undetermined**—As of the date of the announcement, the type of guidance to be used was unknown, but it is expected to be radio-inerital. It is believed that by the end of second-stage burning, the launch vehicle will be within tolerances and that radio correction then can be made before command ignition of the third stage for orbital injection.

Payloads are expected to be small battery powered satellites at first, carrying small checkout experiments or scientific equipment, later being replaced by more complex packages as experience is gained. The latter will fit into the *Ariel* satellite series in degree of complexity.

The government has given development and testing of components and subassemblies as its prime motivation for inaugurating the program, now officially approved and funded. The vehicle's development has been described as giving the UK "an urgently needed space tool" that will allow the nation to contribute more effectively to ELDO, European Space Research Organization (ESRO), and the World Satellite Telecommunications Systems.

Design phase has now begun, and will be handled by the Saunders-Roe Division of Westland, as well as Bristol Siddeley for propulsion. Saunders-Roe developed the original *Black Knight* as a test vehicle for *Blue Streak* components when the latter was under development as a weapon.

Launchings of *Black Knight from* Woomera, the launch site for the new series also, have been handled by Hawker Siddeley Dynamics.

Speculation on a name for the new launcher includes *Black Baron* and *Black Prince*, with the latter being favored.

● **Cost and schedule**—Cost of the project has not been revealed by the Ministry of Aviation, but it will certainly be far less than that for comparable payloads orbited by a booster using *Blue Streak*. Flexibility of the launcher will reduce its costs.

Westland's Managing Director E. C. Wheeldon said both his own company and Bristol Siddeley plan to contribute financially toward the project, but he did not give figures. He confirmed that first launches would probably take place "within three to four years."

The government's hardware contribution will include the third-stage solid rocket, to be supplied by the Ministry of Aviation's Rocket Propulsion establishment at Westcott, Buckinghamshire.

Great emphasis was placed by the government on the fact that the new vehicle is not being developed in competition or as an alternative to ELDO, but instead to make the UK contribution to ELDO and other organizations more effective.

Black Knight's most recent mission has been re-entry experiments in the *Dazzle* program at Woomera, for which the solid-propellant stage was fired in a downward direction to provide high-velocity re-entry. Although the solid propellant motor will be spin-stabilized for purposes of satellite launching, the eventual hope of the UK is that a completely attitude-controlled satellite will be placed into orbit for command from the ground. This will rank with communication satellite experiments in the lead of future objectives. ■

Weak Point of Present Systems Lies At Computer Programming End of Chain

Also needing improvement are film processing, presentation accuracy and flexibility of real-time system status or tactical-situation displays; market expected to grow slightly in decade

LASER, electroluminescent, electrostatic, and coherent fiber-optic systems are all potentially good approaches for future advanced displays.

But today's needs appear generally to be satisfied by conventional or state-of-the-art methods at the display generation end of information or sensor systems. The weakness, according to industry experts, lies with the computer programming end of the information chain. Problems now are generally related to how to process a variety of inputs, summarize, address, store and retrieve data rapidly and reliably.

Secondary, but nevertheless important, improvements are needed in film processing, presentation accuracy, and in flexibility of real-time system-status or tactical-situation displays.

● **Market steady**—Dollar estimates of today's display market by industry are nearly meaningless—they vary from $200-450 million a year. The problem of estimating a market for such subsystems is in not knowing where to draw the line. Does the display system begin with the computer interface, is it just the ultimate display generator, or does it include display call-up consoles, programmers and other supporting equipment?

Further complicating the market as far as dollars are concerned are those systems whose display or readout unit is an integral part of the system—such as radar or sonar displays.

Display manufacturers, in general, look to a steady market over the next 10 years, with only a slight growth tendency.

Command and control system displays, on the order of $1 million each, are expected to continue at the rate of 25-30 a year for at least 5-10 years.

The need for improved hardware in large numbers appears greatest for vehicular control—particularly for aircraft.

Improved heads-up displays, vertical and horizontal situation displays will be needed. The trend, however, will certainly be for such units to be a part of an integrated avionics package. The two Navy programs, ILAAS (Integrated Light Aircraft Avionics System) and IHAS (Integrated Helicopter Avionics System), and the avionics systems for the Air Force and Navy versions of the F-111 (TFX) are typical examples of this approach.

RFQ's are expected soon for an integrated cockpit display system for the Army from Ft. Monmouth and the Navy's Office of Naval Research is expected to issue RFQ's soon for a terrain-avoidance radar display system.

An unknown quantity now is the display requirement for upcoming

Special Report on Advanced Displays

IN THE FOLLOWING pages, MISSILES AND ROCKETS *Electronics Editors Charles D. LaFond and Rex Pay present an up-to-date survey of advanced display systems—for space and missile applications and other fields as well. The first article covers the overall picture and the market outlook. The second (p. 31) reports on advanced techniques. Next (p. 38) is a discussion of command and control systems, and finally (p. 43) a look at spacecraft cockpit equipment.*



UNIVERSAL SYSTEM BOARD now in use at Defense Communications Agency's Operations Center near Washington, D.C., shows status of terminals and circuits for the global military telecommunications system. The computer-fed display system, installed at three Area Centers as well as the National Center, was designed by Philco Corp. and International Business Machines.

manned spacecraft beyond *Apollo*. The Air Force *Manned Orbiting Laboratory (MOL)*, will require both flight hardware and possibly a separate ground control center. Programs such as this, however, will not significantly change the market.

Based on the number of current study and design contracts, Navy tactical C&C systems seem to offer an expanding field for future display systems. Franklin Institute, Philadelphia, probably the leading organization in the country in the field of C&C systems design, now holds ONR contracts to determine requirements and design C&C displays for 12 Navy commands. These include systems for the operations centers of CINCLANT Fleet, CINCPAC Fleet, ASW FORLANT, Alaskan Sea Frontier, CINCUSNAV Europe, and the First, Second, Sixth and Seventh Fleets.

Radio Corp. of America is performing a contract for Navy Electronics Laboratory, San Diego, Calif., to determine requirements and design a large screen display system as a part of a shipboard automated communication system for use in the 1970's.

Litton Industries, Inc., is performing a simular study for the Bureau of Ships for updating the Naval Tactical Data System, but for earlier implementation.

● **Programming considerations**—In the face of the growth in complexity of the programming problem associated with present data display systems, there is a feeling that on-line programming will eventually become a feature of advanced C&C systems. The lack of experience with this kind of operation and the prospect of new untried computer operations being inserted into a mission make operating staffs extremely cautious about this development.

As far as large-screen group displays are concerned, enthusiasm is often expressed for the dramatic effects they can generate for the visitor's gallery. Criticism of their performance, however, is often strong among operating staffs. Part of the problem comes from the differing availability of information at individual display consoles.

If an operator has a display console that will show on demand an aspect he requires of a mission, the large screen is not of much concern to him. On the other hand, if his personal display is limited, and the large screen is showing data of significance to him, his attention is divided and the limitations of the large screen—poor light contrast, low speed, and often low accuracy—become apparent.

D. D. Meyer, group supervisor at Jet Propulsion Laboratory's space flight operations facility, has suggested that there is a need for an "electronic blackboard," a large wall display that can be seen by all people in a control room and can be altered remotely from any position in the room.

This is perhaps an example of a particular environment generating a particular requirement—habit plays a large part in subjective preference for displays. In this case, it is perhaps a reflection of the academic habit of discussing things on a blackboard. There is, however, a school of thought that holds that such discussions are best held in support areas outside the main control center, or at least restricted to the personnel immediately concerned. This viewpoint is best satisfied by a switched TV system with a conference capability.

● **Displays distrusted**—A problem uncovered by Space Systems Division of the Air Force in its satellite control operations is that operators tend to distrust visual displays and prefer verbal messages. Attempting to get this verbal information is time-consuming and defeats the object of the display. Only successful operating experience, however, develops the necessary confidence for complete reliance on the visual display.



FLIGHT PATH Status Console, installed at JPL's Space Flight Operations Center near Pasadena, Calif., shows two of many TV monitors that draw on data provided by over 100 Cohu TV cameras used in massive closed-circuit video complex.

The computer read-out printer or teletype machine is still a basic essential in operations control, but the state-of-the-art lags far behind required quietness of operation.

Rear Adm. L. D. Coates, Office of Naval Research, has identified as the next big step forward in use of computers the ability to obtain help from the machines themselves in more rapidly formulating problems and finding methods for solution.

This can be accomplished by an on-line technique in which man and computer work together, feeding information back and forth to each other, the man guiding the process. Inevitably the success of the procedure depends heavily on the display system used .

Bunker-Ramo Corp. has become a prime mover in development of special techniques of man-machine communications.

● **Man-machine link**—The aim of the man-machine system is to have man make the complex decisions and have the machine assist him. To this end Bunker-Ramo is developing on-line programming to couple man and the machine more effectively.

Primary problem at present in this type of operation is the inability of the commander to pose unprogrammed hypothetical questions of the form "What happens if I carry out such-and-such an action, and what numbers are involved?"

H. L. Shoemaker, director of the B-R command and control systems laboratory, points out that these types of inquiries may very well involve the selective retrieval of information from the data base and that development of associative memory techniques will facilitate the operation of displays in this manner.

Shoemaker thinks that current cost-effectiveness Defense Dept. policies will lead to much closer scrutiny than in the past of whether refinements in C&C systems that call for additional computer instructions are really needed. "I think that this will cause future systems to be considerably less sophisticated and rely more completely on man, rather than on complete automation of a machine," he says. This in turn will place heavy emphasis on flexible display systems.

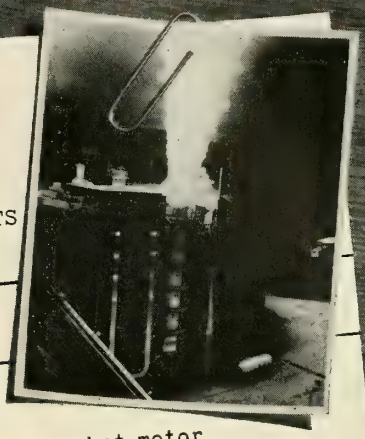
● **"Software" problems**—The most difficult and challenging aspect of automatic data processing in C&C is not in hardware but in "software." Fred A. Payne, deputy director (Strategic and Defensive Systems) Department of Defense Research & Engineering, has said that transition of software from development into operations is a major technical problem.

Speaking at the Ballistic Missile and Space Symposium, Payne warned of the difficulties facing advanced display systems: "Not only are the equipment and programming problems more complex, but real psychological factors are added. . . . the information needed to make operational decisions is not easily quantized. The equipment and programming problems become staggering when we are faced with a need for flexible displays that can relate data from any of many files on very short notice . . . .

"Decision-making staffs expect dis-

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Cost isn't the only advantage of UTC's 120-inch solid propellant segments



SUBJECT: 120-INCH SOLID PROPELLANT ROCKET SEGMENTS AS BASIC POWER UNITS

Company: United Technology Center

Background:

The segmented 120-inch diameter solid propellant rocket motor is being developed for the Air Force by UTC. Two five-segment motors will be used as the booster stage of the Titan III-C.

Advantages:

The 120-inch segments are simple, reliable, versatile, basic power units.

They can be mass-produced in present UTC facilities, easily transported, and can be stored for long periods of time. At the launch site, they can be rapidly assembled into a variety of configurations.

Because of the adaptability of these segments, they have numerous applications. Assembled into complete motors, they can be used for advanced ballistic missiles to increase payload and range, and for thrust augmentation of larger vehicles. Clustered, the solid rocket motors can be used for complete missile and space launch systems.

Clustering of 120-inch segmented solid propellant rocket motors will enable UTC to meet future space needs by providing vehicles capable of thrusts in the range of 20 million pounds without extensive development programs or facilities expansion.

Further reference: write UTC, Sunnyvale, California

United Technology Center DIVISION OF UNITED AIRCRAFT CORPORATION

plays without being clear why they want them, or appreciating the restraints which elaborate machine-generated displays may impose on their normal free way of doing business."

Taking an overall look at information displays for aerospace surveillance, Curtis E. Wolfe, USAF Air Defense Command, has pointed out that the best and most efficient surveillance system will not achieve its purpose unless it can rely on an integrated information system incorporating display capabilities that are responsive to the commanders. He feels that the state of the art in individual and group displays has not achieved the ultimate in information display requirements. He foresees a need for electronic displays with multicolor performance, multiformat capability, alphanumeric data presentation, adequate brightness, and 1,000-3,000-line resolution.

● **Use of color**—Color in displays is a subject for heated discussion. While it can have an extremely important role in speeding assimulation of information, it can also generate confusion if misapplied. Problems of color blindness and subjective response to color also arise.

In some cases, the advantages of color can be very clear. Experiments reported by GPL Division of General Precision, Inc., show that in counting different military symbols (ships, aircraft, radars, etc.) on a map-type display, differentiation of the symbols by color produced a 69% increase in speed and 76% fewer counting errors.

GPL, for example, has developed the LentiColor system, which presents original black and white film images in full color through a single lens system. Briefing slides are available in 15 seconds by this process. The DataColor system, also developed by GPL, presents a similar capability for television systems: standard black and white vidicon cameras view black and white or color objects and present the subject on color television displays.

Five or six colors are the practical limit for the eye operating without reference to a color code. Each color is arbitrarily selected according to the brightness of the subject. For instance, dark portions might be shown in red, medium shades in blue, and light shades in green.

A sometimes-neglected aspect of displays, which nevertheless influences military procurement considerably, includes logistics, operating cost, and availability of the equipment.

The normal military logistics problem is in many ways compounded by the necessity of high logistic support in the form of expendable film and chemicals to keep displays going. Operating costs are influenced the choice of film and chemicals and also by the very high cost of components with relatively short life, such as xenon lamps and cathode ray tubes.

Trade-offs, such as film cost and reuseability, cathode life and replacement time, and the decision to re-use or throw away chemicals, are highly critical. The Air Force has recently undertaken a program to obtain data and quantify considerations such as these.

● **Command & Control**—Advanced display systems today form an integral part of all large information systems—whether the output be merely printed text, tabular data or a multicolored, multi-functional dynamic situation display.

For convenience, C&C display systems can be separated into three areas —strategic military systems, tactical military systems, and missile/space control-center systems.

In general, the greatest need today for C&C displays is not for more exotic or more complex readout generators but rather for improved data processing and addressing. To generalize further, the need is more on the programming side than on the equipment side.

ADP software improvements, say industry leaders, are most needed for strategic systems, in which the present display state of the art is sufficient. Precision needs exceed short time response. However, as the need for faster response time and flexibility increases for tactical or launch operations, so does the need increase for better display systems.

● **Standardization lacking**—Dr. Carl A. Silver, a leading scientist in the field of strategic C&C display system design criteria at the Franklin Institute, likens display in this field to that of the computer field 10 years ago. Systems and subsystems have not yet found any level of standardization. Many displays and different techniques are in use or are being developed and most have the same system objectives, says Silver.

Out of all these, only a few major techniques will survive during the next five years, he predicted.

For C&C systems today, four principal types of group displays are receiving most active development:

—Projected, using a photographic film or selenium plate as a stable light modulator.

—Electromechanical, including large digital X-Y printer plotters, Vu-Graph scribers for overhead projection, alphanumeric drums and matrices.

—Electroluminescent panels, offering full color, large surface and high brightness.

—Electrostatic, including oil-film light valves and thermoplastic recording/projection.

Projected displays are presently state of the art and are available in many forms. Emphasis here is in improved film and processing and in updating, storage and retrieval of slides—all efforts centered on reducing response time.

Electromechanical systems offer relatively slow response but quite accurate location and track data. While they avoid the problems of film handling and processing, they are inherently subject to mechanical wear and breakdown.

Electroluminescent displays offer potentially great simplicity, the opportunity to bypass projection, since the image surface is both light source and modulator, and an inherent reliability. (Contrary to early developers' huckstering, electroluminescent panels are subject to degradation, although they are not subject to catastrophic failure in the normal sense.)

Practical large systems are still several years away. New phosphors are being studied to improve brightness and multicolor and modulation methods are receiving the greatest development effort.

Electrostatic systems are now available for low ambient lighting display conditions but much more development is needed for use in higher lighting operating areas. They offer good response time and film recovery, but brightness and resolution must be improved before systems find broad acceptance.

● **Individual displays**—Most hardware progress is being made in displays for individual operators, notably by the use of switched television monitors to present computer-sorted information. In these, several operators have access to the same data base, but each can select his own display information, presented in a format most useful to his needs.

A further refinement may be the ability of several operators to call up the same display on their individual monitors, and, with the aid of an electronic pointer, discuss various features.

Main problem area in this type of display lies in programming the computer system that drives it. This is becoming an increasingly complex task as the need to call up data in very flexible categories increases. Unfortunately, this tends to be an important requirement in advanced display systems. It is difficult for mission controllers to predict exactly what categories of information they will require on a display when, in many cases, they have only general experience with the mission they will be controlling.

The state of the art of data bases and displays has advanced rapidly over the past two years, but there is no operational experience available in many instances to indicate how this art should be applied. The result is a cautious approach to individual data-display systems, with emphasis on flexibility and a capability to expand. ■

Variety of Techniques Holds Promise

Different display requirements are fostering numerous solutions, some straining state of the art; use of lasers foreseen; 3-D units disappointing

DURING THE NEXT few years advanced displays will make increasing use of electroluminescent panels, light valves, thermoplastic tape recording and projection, fiber optics, and photochromics.

Research work is continuing in even more exotic approaches, including laser displays and three-dimensional image presentation. The latter so far have not shown sufficient potential to warrant much government R&D support. Application of lasers to displays is now only in the embryonic stage.

Dynamic plotting projecting displays are now coming into wider use and it is expected that intensive R&D will produce a whole range of graphic generating devices for large displays.

The following summarizes the state of the art in each of the major areas of advanced display techniques.

Electroluminescence

Main advantages of electroluminescent displays that are spurring their development are high reliability and low power consumption. Problem at present is low resolution.

The promised advantages would pay off in spacecraft, but it is in this application that small, high-resolution displays are essential. Main area of research still lies in the examination of phosphors to get increased brightness, resolution and response.

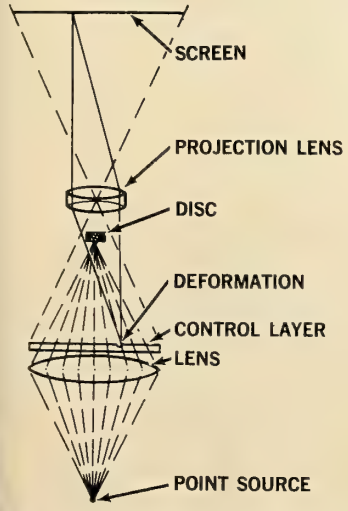
There has been considerable progress in the past two years in getting sufficient brightness, in developing multicolor displays, and in increasing resolution. But resolution is not good enough yet for spacecraft use, by an order of magnitude. It may be five years or more before EL displays become as good as present-day TV displays, which are already becoming more of a high-reliability device than is generally believed.

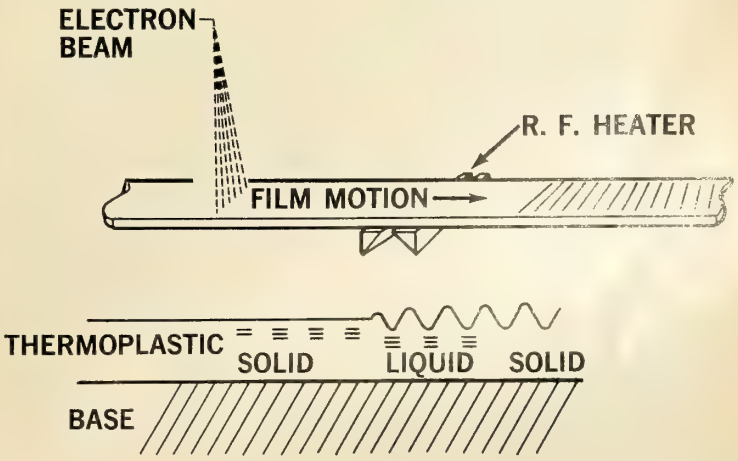
A basic EL panel consists of a thin film of EL phosphor in ceramic dielectric, sandwiched between two thin transparent conductive films, the whole structure being less than 0.01 in. thick and deposited on a glass substrate. Display has no parallax and no catastrophic failure mechanism such as filament tubes have, but the brightness of the display decays with use. Typically the half brightness level is reached after 1,000 hours.

First use of EL is to frame instruments and provide simple indicators, replacing filament lamps.

• **Other EL's**—More complex is the segmented vertical display, or thermometer type. In this the top of an illuminated column is the readout point. This can be used to indicate velocity or

SCHEMATICS show (left) a typical light valve projection system and (right) the principle of thermoplastic recording.





stored propellant reserve, for example. Resolutions of 30 lines per inch are about optimum for this type of display, but higher resolutions can be produced. A digital input is needed.

Most complex is the crossed-grid x-y panel, in which individual elements at any point in a rectangular display can be switched on to form a wide variety of patterns. A million elements might be needed and access is a problem. Chief approach is to apply half the energizing voltage to the selected x-line and half to the selected y-line. Theoretically, this should produce a point of light at the intersection of the lines. Usual result is for each complete line to give out some light.

To overcome this, the suppressed EL display has been developed, which incorporates an additional non-linear resistive layer between phosphor and electrode strip. This suppresses unwanted light, but the manufacturing process restricts resolution to about 10 lines per inch. Panels of this type are being developed for group displays with an area of about 30 sq. ft.

One problem with cross-grid displays is the need for high-speed activation and refreshment, for which a nanosecond computer has been suggested. Justification for using such a computer would depend on its being needed for other tasks as well.

• **Piezoelectric displays**—To avoid this switching problem, EL piezoelectric displays have been proposed. In these, the phosphor is deposited on a wedge of a material such as $BaTiO_3$. A spot of light can be moved across the wedge by varying the frequency of the excitation voltage: the energizing voltage is enhanced where the thickness of the wedge is such as to resonate with the applied signal. Feasibility of this technique for TV-type displays has been shown, but extensive research is needed to produce phosphors operating in the megacycle region.

Sylvania is said to be the recognized leader in EL displays, but Lear Siegler seems to have moved forward faster with applications, producing EL lighting displays and thermometer-type displays.

Autonetics Division of North American Aviation is investigating piezoelectric generation of the controlling voltage of EL displays. Localized areas of high field intensity are created by strobing an acoustically generated voltage pulse as it travels along the length of an electroluminescent strip. A faster scan is accomplished by combined phase-modulated strobing and channel-strip switching. One-mm images require pulses of about 0.3 microsec and the aim of present research is to develop a more sensitive panel for such short excitation times.

Autonetics is also concerned with image enhancement by use of photoconductive-electroluminescent light amplifiers, to improve low level signals in brightness and contrast and convert outputs to wavelengths of high luminosity. In addition, work is also in hand on the subjective generation of multiple colors from a monochromatic EL display. Five distinct colors have been produced from a single yellow source to date.

Others in the field include RCA, Penn Keystone Corp., Westinghouse Electric Corp., Lincoln Laboratory, General Precision, Inc., and General Dynamics/Electronics.

Electroflors

Electroflors are liquid phase materials that flouresce or change color when activated by small electrical currents. Possible configurations for display applications are large single cells, single-dot displays, multiple-dot configuration displays, flat-plate matrix displays, and three-dimensional tank displays.

A matrix display of the crossed electrode type was produced by Electroflor, Inc., for the Air Force. It showed spurious light in a way similar to the unsuppressed luminescent crossed-grid display. A solution is to use anodic electrodes, but the image produced cannot be removed electrically—it must be allowed to decay over its normal afterglow period.

Limitations of electroflors include slow response time (usually more than 0.01 sec.) and the need for complex circuitry for switching data into complicated displays. Potential advantages include visibility under bright ambient illumination, ease of shaping displays, availability of several colors, requirement for low energizing voltages and currents, color indications that remain for an afterglow period up to several minutes, and production of large displays with small thickness.

• **Electrostatic techniques**—Two considerably different display approaches using electrostatic forces to impress information on a material surface by deformation are now receiving considerable attention in industry. One is the light valve, using an oil film as the medium, and the other is thermoplastic tape recording.

For projection, both use modified Schlieren optical systems.

Two general approaches are used today for light valve (or control layer) devices: Theater Network Television, Inc., produces a commercial system wherein light is reflected from a spherical oil-coated mirror; General Electric Co. is developing systems for military use that transmit light through an oil-coated disc.

An electron gun, in both techniques, is used to lay down a charge pattern in

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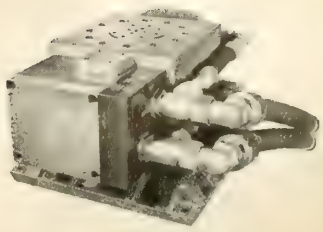
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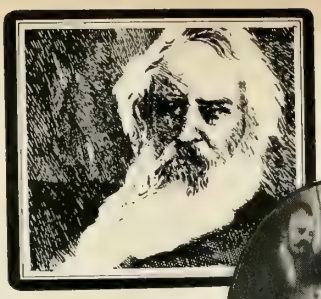
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1844/Morse – First telegraph message sent.

1858/Field – First trans-Atlantic cable laid.





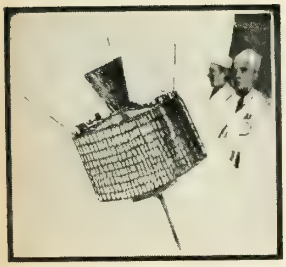
1876/Bell – The first telephone call.



1901/Marconi – First wireless sent across the Atlantic.



1941/NBC – First commercial television.



1963/HUGHES and NASA – First successful synchronous satellite stationed over the Atlantic.



September 11, 1964/
HUGHES and NASA – Syncom opens first 24-hour TV and radio communications between the Far East and the West.

On September 11, Syncom became the first satellite to be "parked" over the Pacific Ocean. From its position, 22,300 miles high over this vast expanse, it brings to practical reality a dream of ages – giving mankind 24-hour, uninterrupted trans-Pacific TV and radio communications.

One of its first achievements will be to bring you the 1964 Tokyo Olympics "live," not on film. Built by HUGHES for NASA, this satellite is another step forward in the development of a satellite communications system which will be affordable by all the nations of the earth.

An earlier Syncom has been operating successfully for more than a year. Next year, a HUGHES Syncom-type satellite will be put over the Atlantic for the Communications Satellite Corporation. As the first publicly owned satellite, it will bring the continent of Europe close as your telephone and television set. Engineers and scientists are invited to inquire about careers at Hughes – an equal opportunity employer.

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Products like Syncom, devised to let mankind share in the fruits of science, illustrate how Hughes is creating a new world with electronics.

the oil. Electrostatic forces between the charges and a conducting base layer create depressions and adjacent ridges. The sloping ridges refract light around an aperture disc. Light rays striking a non-deformed area are directed toward and blocked by the aperture disc. Refracted rays are collected by a lens in the projection system and the resulting focused image on the screen resembles that produced by conventional CRT. Image persistence depends on rate that the deformations subside.

In thermoplastic recording and projection systems, an electrostatic charge pattern generally is formed with an electron beam in a thermally softened surface—analogous to a silver-halide latent image. Tapes are recoverable. Approaches, however, vary considerably.

Litton Data Systems and Omnitronics, Inc., use a CRT whose faceplate is pierced with a series of conductors to form a charge pattern directly on the tape. No precharge of the storage medium is needed and no photoconductor is needed. Definition is limited by the faceplate wire spacing and also to image blooming due to use of the large beam, capacity between wires, ionization, and other anomolies.

Xerox and RCA devices lay down an even charge first, then dissipate the charge under controlled conditions by means of a photoconductive layer exposed to an optical image. The technique is more complex but definition is limited only by the optical system and the graininess of the processing step. Exposures can be made at 10^4 symbols/sec.

General Electric uses a crossed matrix of conducting lines—one set under the thermoplastic and one above in air. Charges are deposited only at line intersections. Present capability is up to 500 dots per linear inch.

With the above systems, images are developed either by toning with the deposition of colored dust or by deforming the thermoplastic to redirect light. The former, used by Litton, is best for line drawings or for large area outlines.

With thermal deformation, definition is high. General Electric, RCA, and Xerox employ this method.

Omnitronics tones with tiny glass beads achieving a 41/1 control. The approach requires reflective optics and Schlieren stops.

Three-dimensional Displays

Three-dimensional displays form two main groups—volumetric displays and illusory displays.

Volumetric displays use the intersection of guided energy in three-dimensional space. At the point of intersection the energies sum to produce light.

For low data rates, movement of particles in a volume has been proposed. Typical of such devices is Chrysler's inked servo-driven stylus moving in a volume of gelatin, which operates at a low data rate and handles few targets.

Electroflor, Inc., has suggested use of a tank of clear electroflor liquid in the form of a soft gel. A color-forming electrode is carried around in the gel by a system of racks and pinions. As the electrode moves through the tank, it produces a trail with a brightly colored head and a tail that fades rapidly.

To handle more realistic data rates, volume scanning by a flying spot has been proposed. Attempts to produce glow spots at the intersection of cross-wire matrices in a gas have not had much success because of low resolution, vision blockage by wires, and switching and wiring complexities. An alternative approach, stacking several transparent CRT's in depth suffers from limited depth resolution and multiple reflection.

A more promising approach is to use a screen or surface that rotates or oscillates through a fixed volume. A point of light is produced on the screen either by direct energising, such as in an electroluminescent display, or by means of an optical system.

A primary screen system using a non-suppressed EL cross-grid matrix panel is being developed by Avco. The screen rotates at about 20 rps about its vertical axis and a bright spot is produced at the intersection of selected energized lines. Electronic pulse gating of the panel produces a display of moving spots of light in three dimensions.

The developmental model requires about 17 watts and no special optics, but use of an unsuppressed EL matrix means poor resolution and poor light output characteristics. Also, the slip-ring connector to panel has limited life.

ITT is developing a secondary-image display in which an image from a high-intensity CRT is projected onto a rotating screen by optical means.

GE uses a specially shaped screen illuminated by a high intensity light source. A scanning mirror directs the beam to any desired point on the rotating screen, and a shutter system enables display of up to three targets.

All three of these displays have resolution problems and poor light intensity.

A special problem is, in fact, posed in obtaining resolution in depth, because this depends not only on the display, but also on the ease with which the eye can perceive resolution in depth. Many of the perceptual aspects of volume displays have not been evaluated, and these may in fact be the very aspects that limit the value of 3-D techniques.

● **3-D drawbacks**—Illusory three-dimensional displays usually have one of two disadvantages. Either the observer must occupy a rigidly fixed viewing position, or he must wear glasses. Also, some people simply cannot adapt to the stereoscopic presentation.

Stereoscopic displays of radar data have been developed by Hughes Aircraft and others. In the Hughes system, two direct view storage tubes present the same scene as seen from two different positions. Polarizing filters and silvered mirrors are then used to project a different image to each eye. To perceive the resulting visual parallax, the operator must wear polarized glasses.

Another scheme uses a half-silvered mirror attached to a headband so as to be very close to the operator's eyes. Two one-inch CRT's are held alongside the man's head by the headband so that he sees enlarged images when he focuses to a distance less than a foot. The two images are a stereoscopic pair, producing an illusory three-D image. When the operator focuses beyond one foot, the images are said not to interfere with his view of distant objects.

● **View without a window**—Another class of three-dimensional displays are the optical systems used to present a view of the real world to the occupants of a spacecraft without incurring the structural penalty of large window areas.

Marquardt is investigating techniques for application of its "Vuemarq" system for aerospace vehicle visual simulation requirements. The system is said to produce high resolution, distortion-free images with a field of view approaching that of a complete sphere. Two mirrors that have conic sections of revolution with reciprocal eccentricities are used. The mirrors share a common focus and a common axis and have an optical stop that passes only the rays reflected through the common focus.

For the simulator display, the light magnification of a camera-projector system is used to give a bright image, a field flattener being used to focus the image over a flat piece of film.

Field of view is about 360 degrees in azimuth by 270 degrees in elevation. The image is presented as a virtual image focused at infinity rather than as an image displayed on a screen or CRT. This enhances the simulation of depth, perspective, and spatial orientation.

Studies on the visibility required by a pilot for the various phases of flight are being carried out by the NASA Flight Research Center, Edwards AFB, Calif. First tests were made with about 40 flights in a two-place light aircraft, a U.S. Army L-19, fitted with two wide-angle monocular telescopes. This program is being extrapolated into tests with an F-104B, the low L/D of which approximates that expected of ground-landing spacecraft. The optical system is being further developed by replacing the two viewing eyepieces with a spherical mirror with a large exit pupil, which will enable the pilot greater freedom of head movement, while still seeing the outside world. ■

Digital Computer-TV Displays Gaining Favor for Operations C&C Use

Fast, selective access afforded outweighs higher costs and complex programming; large screen displays remain popular in some roles, but ambient light is problem; individual installations discussed

DISPLAY SYSTEMS in operations command and control are tending toward greater use of digital computers coupled to television display systems. Chief advantages of this technique are rapid and selective access to information. Problems are the complex programming needs of such systems and their increased hardware costs.

In switched television systems that rely on character generators coupled to a central computer, large screen displays are becoming of less value. In less complex systems, the large-screen display still has an important role. Chief criticisms from users of such displays have revolved about their slow speed, poor viewing characteristics and unreliability. Recently, improvements in reliability and response time have been made, but ambient illumination still presents a problem.

To best show current state of the art in displays for C&C-type systems, a few of the major approaches, now either in being or about to be, follow. These typify use of current technology, for among these systems may be found the successful, the not-so-successful, and the untried.

Missile/Space Displays

● **Manned Spaceflight Control Center**—Main feature of the Manned Spaceflight Control Center is the provision of two independent Mission Operations Control Rooms, each with a full complement of displays and computer facilities. Emphasis has been given to use of a large digital computer (IBM 7094) as a basic means of initiating and generating displays. All functions not initiated by push buttons are initiated by a computer. For example, about 5 kw of pilot lights are turned on by the 7094, this being considered the cheapest way to carry out this function.

Principal contractor for the MSCC is Philco/Houston, with computer programming being supplied by IBM. Each MOCR has about 17 individual display consoles, each carrying two 14-in. high-resolution television monitors. At the end of each room are large-screen group displays, similar to those used in the *Mercury* program.

As yet, detailed features of the *Apollo* displays have not been worked out. Much depends on the experience gained with large scale simulation of MSCC operations and with the *Gemini* flights. The design of the MSCC has emphasized flexibility in display presentation, and sufficient capacity is believed to be available to plot anything that is needed, although there is a limit on the input rate for radar data. Studies are under way to see how the three-dimensional trajectory to the Moon can be best represented.

There are two projection plotboards in the group displays. One will be used for spacecraft altitude versus distance plots, flight path versus velocity rate plots, and impact point plots. The other will be used during launch to display plots of *Gemini* launch vehicle trajectory quantities. An eight-spot projection system supplied by Ling-Temco-Vought is used, the spots being computer driven.

On either side of the projection plotting displays are located 945-line projection television displays, supplied by Theater Network TV, Inc. The pictures can be mixed with background slides and computer data.

There are in fact three television display systems in the MSCC: the projection displays, the console displays, and large TV monitors to show time.

The major part of the information for the console monitors will originate from character-generator equipment supplied by General Dynamics/Electronics. There are 56 digital/TV converters in the MSCC that convert computer information to a visual display by means of Charactron tubes. A closed-circuit TV camera views the tube display, on which 35-mm slide file data can be superimposed. Images from these cameras are routed through a 20-mc wideband switch to the consoles.

Presentation at the console monitors is by means of characters positioned on a 1,024 by 1,024 grid, slides providing tabular backgrounds. Other types of displays that can be selected are meter displays and analog plots.

● **Space Flight Operations Facility**—Data entering JPL's Space Flight Operations Facility, used to control lunar and interplanetary spacecraft, is processed by an IBM 7094 and routed by an IBM 7040 to the appropriate personnel. Final information may be printed or plotted in user areas or displayed on a large mission status board.

Subsequent routing and display of this information is carried out by a closed-circuit television system utilizing 100 Cohu Kin Tel miniature cameras. On-line digital data are plotted by DY-6260 data plotters built by Dymec Division of Hewlett-Packard. Printed data



JET PROPULSION LABORATORY'S Mission Control Area, Space Flight Operations Facility, employs generous mix of large-scale wall displays for tabular readout and real-time TV monitors. All are computer-directed and -controlled.

are produced by S-C 3070 Electronic Printers developed by General Dynamics/Electronics. These provide copy at speeds up to 5,000 words per minute and make use of Charactron shaped-beam tubes.

Nineteen display and control consoles with TV monitors are located throughout the SFOF: seven in operational areas, three in technical areas, and nine in control areas. As well as relaying printed and plotted data.

The Mission Status Board forms a special display running the length of a 40-ft. wall at the forward end of the operations area. This can display the status of two missions simultaneously and makes use of about 5,000 electromechanical digital display units made by CBS Laboratories. These are designed for optimum TV camera pick-up. Remote control and posting of these displays is carried out from a Data Processing Control Console.

Also in the wall display is a projection television screen, which shows enlarged TV pictures or slides.

Data processing system inputs and outputs are handled by input/output consoles supplied by Tasker Instruments Corp. A variable-message display in these makes use of a row of four small rectangular CRT's to display a total of 72 alphanumeric characters along one horizontal line. A Tasker symbol generator produces the characters.

A display peculiar to SFOF is the Spacecraft Functional Model. A miniature model of a spacecraft is mounted in a platform free to move in pitch, roll and yaw. Located in a hemispherical room representing one half of the celestial sphere, the model shows the spacecraft's actual resulting flight attitude.

• **NORAD 425L command and control system**—The NORAD 425L system makes use of off-the-shelf components and relies heavily on the television presentation of data. All displays are constructed by sampling a common data base that is under control of the main computer program.

Consoles are constructed so that they can serve any operator. Display make-up and selection is accomplished by a general purpose keyboard and appropriate overlays.

Three main types of displays can be selected. The first is a situation display containing information oriented on specific geographic areas. These displays are selected by use of "category" and "feature" logic. Categories are a combination of similar elements, such as air bases or flight tracks. A feature is a piece of information that describes the elements in a category, such as base weather or track altitude. Also, categories may be filtered with respect to some features by switch action.

The second type of display is the tabular display that appears in a fixed reserved area on the display tube face. These carry dynamically updated tabular information.

The third type of display are those under program control and fixed in format and content. This allows conference displays, in which the same display is shown at two positions, with an electronic pointer provided to aid discussion. It also enables higher echelons to consult the data base directly and discuss a specific topic with the responsible operator.

Wall displays in the 425L system are a projected image of a console display with the addition of color coding. The contents of the wall displays can be controlled by any designated console.

• **SPADATS**—The main display at NORAD's Space Detection and Tracking System (SPADATS) is of the large menu-board variety, carrying alphanumeric symbols that are positioned manually. A picture of this board is piped via closed-circuit TV to the neary Combat Operations Center.

A more complex display system may be used in the future if SPADATS becomes equipped to provide warning of hostile activity in space, to show threat potential of unfriendly spacecraft, to provide space traffic control, and to support anti-satellite weapons.

• **Shipboard Satellite Display**—The Navy is evaluating a shipboard system that stores orbital data on 100 selected satellites and presents a display of the present and future track of any 10.

Developed by the Naval Research Laboratory, the Satellite Position Prediction and Display equipment (SPAD) enables satellites to be selected for display according to their origin and function. Computation of orbits is carried out by a TRW-300 computer.

Orbits of satellites are displayed on a world map. The operator can also expand and offset the display about a selected satellite. Display generation is by means of a Charactron tube.

Ship's position, course, and distance made good are shown on the display. Alongside each satellite are located symbols showing category, velocity vector, track number, and altitude.

• **New Satellite Test Center Displays**—A two-year program for augmenting the capabilities of the Air Force Space Systems Div. Satellite Test Center at Sunnyvale, Calif., is leading to development of a new automatic data handling system. Inherent in this is the pursuit of an improved display capability, which will be based on the use of television displays operating in conjunction with character generators tied to a central digital computer.

The system will probably receive funding in FY'65 and '66.

SSD notes that a problem with alphanumeric displays in the past has been that they tend to load up the computer and so reduce data processing time.

Col. Howard Norwood of SSD explained that while experience had shown that certain events and parameters needed continual attention, there are unexpected events that create a need

MORE HIGHLIGHTS FROM RYAN'S

SPECTRUM OF CAPABILITIES





NEWEST RYAN V/STOL is Army XV-5A, lift-fan research aircraft built under contract to General Electric. Designed to take off vertically on no more power or fuel than is needed for high speed cruise, the XV-5A is now in flight test.



OVER 6,000 FLIGHTS have proven the Ryan Firebee target missile the most versatile for realistic training and accurate evaluation of weapons systems. Economical, too. This Firebee has already flown 36 separate missions — so far!

ELECTRONIC "CUSHIONS" FOR LEM

A "soft" lunar touchdown is vital to man's hopes of landing himself on the moon.

The landing radar which will provide altitude and velocity data during approach of the manned Lunar Excursion Module to the surface of the moon is among the space projects on which Ryan Electronics is now engaged.

The unmanned Surveyor lunar "soft landing" vehicle will have similar Ryan-designed radar altimeters and Doppler velocity sensor equipment. Ryan high altitude radar altimeters will also provide tracking information for Saturn boosters which will be carrying space-bound payloads.

But space electronics — and space structures — are only two segments of Ryan's spectrum of capabilities.

Ryan is the world's most experienced designer of V/STOL aircraft. Ryan built the world's first universal Doppler navigator for all types of aircraft. Ryan's Flex Wing, a new concept in logistics, is demonstrating marked capabilities for military use.

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to look at points not programmed to be available. SSD is therefore favoring an ability to call up special discrete static displays quickly, rather than to display some dynamic data continuously.

The new STC main control room will have two sets of consoles: one for the system controller, the other for individual operators assigned to subsystems. There will also be large wall screens (about 6 ft. square) on which static displays can be projected. All displays will be installed to operate remotely on a call-up basis in data analysis and technical directors' rooms.

Types of displays planned include discrete, analog plot, alphanumeric and alarm. Goal of the system is to provide grouping and combinations of information in accord with an individual's needs. Included in this is the ability of an operator to select the type and rate of a display on his monitor.

Incoming information from spacecraft will enter "bird buffers" and then pass to a computer select and cross connect unit. This is coupled to a series of display interface buffers and character generators that feed the TV displays.

On the monitor, a typical discrete display will show whether an inverter or control gas system is in or out of limits. A dynamic telemetry/command verification display will indicate such things as system time, telemetry identity, value, functional verification, and noise levels. A third display will show the status of the Satellite Control Facility, that is, the STC and the network of tracking stations that serve it.

Chief advantages foreseen for the new system will be increased use of a digital computer as an aid in decision making and more efficient presentation of information to operators.

• **ETR Control Center**—Aim of the new Eastern Test Range Control Center is to enable the simultaneous countdown of two missile launches and the global support of another orbital vehicle. The Range Control Center will be divided into three operations areas to handle the three missions.

On the main display wall of the center operations area will be an 8 x 8-ft. trajectory display, a status board for 200 launch instrumentation systems, a status board for 200 world-wide instrumentation sites, and time displays.

The trajectory display will allow four missile trajectory plots on any one of four backgrounds, the plotting commands being generated by a digital computer. Missile impact prediction plots and radar displays of range aircraft positions will facilitate recovery operations.

There will be 64 operators in the center, each having voice communications with other operators in the RCC, and with operations personnel at Cape Kennedy and downrange sites.

Contractor to the Air Force for the new Range Control Center is Sperry Piedmont Company.

• **ETR telemetry display**—A Real-Time Telemetry Data System Display is now under development for the Eastern Test Range by RCA's Missile and Surface Radar Div. Heart of the system will be the firm's new Fiber Optics Projection Display.

The system basically employs a random access reference slide projector to vary the projected format background through folded optics to a rear projection screen on the console front. A data projector matrix contains 15x20 individual projectors, each capable of providing up to 12 different symbols or characters. Each of the latter is lighted, upon computer direction, through noncoherent fiber-optic light pipes from a single high-intensity light source. Also directed through the folded optical reflecting system, the matrix image is superimposed on the reference image, providing a dynamic status report in essentially real time.

For the ETR application, the display will be able at all times to show upon operator call-up; overall range telemetry readiness; dynamic station operation during launch, including hand-over control; central facility checkout status; and station checkout status.

By employing a beam splitter and adding a high speed projection plotter, a continuous trace rather than discrete indication could be scribed on the display screen.

The system, being built under an Air Force contract, will be installed at NASA's Merritt Island Launch Facility next year.

Strategic Systems Displays

• **Four major war rooms**—System design for the Army War Room at the Pentagon was performed by Franklin Institute. The organization also has completed the war room system design for the Army Chief of Staff's advanced relocation site.

Franklin is currently engaged in the design of another for Headquarters, Commander in Chief, U.S. Army-Europe at Camp De Loges, France, and is a participant in determining requirements for the National Military Command & Control Center.

The Army War Room at the Pentagon, said Dr. Carl Silver, who has taken part in all of these Franklin Institute studies, is typical of most high-level military strategic information centers.

The display system includes four large wall screens, six display consoles, and a high speed printer-plotter. The computer-fed system is electromechanical and will provide all needed displays by way of a CRT-film-diazo chain in less than 10 minutes from call-up to presentation.

The need for display accuracy and reliability, Silver pointed out, far exceeded the need for fast response.

Since the system is a part of the National Military Command System, overall requirements called for growth flexibility, no user restraint within the limits of the designed system, very high functional reliability, and uncluttered high visual quality.

To implement installation in a short time, only off-the-shelf state-of-the-art hardware was called for in the system.

Univac Div. of Sperry Rand Corp. is under contract to provide system development, system integration, equipment and computer programs for the Army War Room Information System.

The system uses 19-in. CRT's in the inquiry-response consoles for individual displays and a large screen projection system for group display.

The CRT displays are refreshed at 30 times per second directly from the two Univac-1218 computers. A simple search and retrieval system within the computer combined with an indexing scheme permits less complex operational procedures to be used in the interrogation process.

• **SAC's Project 465L**—One of the largest command and control systems now existing is that being installed at Air Force Strategic Air Command Headquarters at Offutt AFB, near Omaha, Neb. The big War Room soon will house the Project 456L system, which will replace or supplement many of the existing SAC communications and control subsystems. Similar systems will be installed at SAC bases at March AFB, Calif., Westover AFB, Mass., and Barksdale AFB, La.

Developed under the direction of the AF Electronic Systems Div. by prime contractor International Telephone and Telegraph Corp., the massive display complex provides large-screen projected displays of map backgrounds, overlays, and tabular and textual data—the whole in up to seven colors. Hard copy printouts are available on demand.

The display generator and high-speed printer are fed by digital-computer. Digital inputs to the generator are converted to alphanumeric characters or symbols on a Charactron CRT. The resulting image is exposed selectively on three framelets of a 70-mm. silver-halide film frame for color separation next on a Kalvar transparency.

Film frames are automatically delivered to one of four projection stations in the display generator. Thirteen seconds are required for single station update; all four can be updated in 25 sec. Response time for projection of stored data in the random-access film storage file is about 2.5 sec.

• **DCS, global status**—Global system status and area status of the Defense Communication System's nearly

20-million-mile telecommunications network can be monitored at the National Communications Control Center near Washington and at three new Area Control Centers.

First increment of the display system at the National Center was developed for the Defense Communications Agency by the Philco Corp. subsidiary of Ford Motor Co. Permanent wall displays present both traffic and system status by means of three-color light cells. Heart of this system is the Philco S-2000 computer, which continuously updates the wall display panels. Green, yellow, or red lights at each terminal indicate facility status through a "Received Side Reporting" approach. Boards are excited only on command.

In addition, a readout board presents responses to operator queries from the control console. This system employs a modified high speed Anelex printer-projector that electromechanically forms a transparency and rear-projects the text on a 7-ft. wall screen.

Second increment of the system was completed this spring by IBM. The new displays are similar in design to the Philco status wall panels, but are controlled by IBM 1410's. Three systems were developed for DCS's Area Control Centers in France, Hawaii, and Colorado. In addition, IBM supplied two 1410's and one display for the National Center.

● **DODDAC, varied displays**—The Dept. of Defense Damage Assessment Center (DODDAC) includes a CRT console producing up to 720 alphanumeric characters from as many as 64 different problem formats; a computer-fed control programmer that produces display-film chips, assigns their destinations, and directs a display generator. The latter produces composite color separation 70-mm. Kalvar film chips, drawing from a 200-slide magazine containing black and white color separation background negatives. A projector receives the completed display film chips from the generator and projects them in up to eight colors.

After computer initiation, the process to screen projection requires roughly 75 seconds. The projector stores random-access, 200-slide magazines of the filed up-dated film chips. The system provides a completely dry film processing chain, fully automatic operation, and additive color projection from a single optical system.

A slide retrieval time design goal of 4 sec. reportedly has not been met by the system. Also the film chip generation-to-display process exceeds the design goal by at least 15 sec. Reportedly, the system has not yet been able to pass acceptance tests.

The system was developed for the Defense Atomic Support Agency by Thompson Ramo Wooldridge, Inc.

Tactical Systems Displays

● **Limited war needs**—Each type of military operation tends to produce its own special requirements for display systems, and limited war is no exception. Fairchild Space and Defense Systems is delivering reconnaissance data reduction shelters to the Air Force and these exemplify the sort of thinking that is behind efforts in this area. Aim of the system, called the Limited Warfare Intelligence Reduction Complex (LWIRC), is to furnish Air Force commanders with up-to-date intelligence on tactical targets. Key element of the semi-automated photointerpretation system is a multi-sensor viewer/printer console for simultaneous display of panoramic and frame photography as well as side-looking radar and infra-red imagery. A modified Univac M1218 digital computer system and teleprinter equipment cut down many of the routine time-consuming chores of the three-man team.

The shelter is air-transportable and intended for forward areas of operation. On return of a reconnaissance aircraft, reels of developed film are mounted on the multi-sensor viewer, which displays 70-mm. to 9.5-in. multi-sensor films on four viewing channels for target detection, comparison, and analysis.

Display units for the system are being developed for Univac by Raytheon and a high-speed printer was built for the Sperry division by General Dynamics/Electronics.

● **Shipboard communications status**—Under the direction of Dr. Fred Ireland at RCA's Moorestown, N.J., facility, the Missile and Surface Radar Div. is performing a 9-month, 3-phase study: to (1) review large screen display techniques applicable to shipboard use, (2) determine what would be needed to present ship and shore communications network and circuit status and select potential subsystems, and (3) finally to design a practical system for use in the 1970 time period. Work is being done under a $100,000 Navy Electronics Laboratory-San Diego contract.

A complex system is envisioned to present network and link status. Terminal status, communications equipment monitor and status, and equipment module summary status. The computer-controlled system will be designed for a 1-sec. single-change or under-20-sec. total-format-change response time.

● **ARTOC, CRT-to-film**—The Army Tactical Operations Central (ARTOC) employs basically a cathode ray tube-to-film system for its displays. A 5-in. CRT (magnetic deflection type, 1,500x2,000-pt. matrix) is used to expose 35-mm., black-and-white, silver-halide bulk-roll film. Film handling is completely automatic. Twelve seconds are required from input to dispaly.

Following a 5-sec. wet-process development, the negative is contact-printed on Kalvar diazo film to form a positive transparency. The latter are permanently pre-mounted for storage, retrieval and subsequent use. Slides are pneumatically delivered for display.

Ultimate group projection is by an 1,800-watt xenon arc lamp for a 7x9-ft. screen image. The system, using a split projection beam, allows for use of one full-color 70-mm reference slide and up to four 35-mm overlays.

The system was developed for the Army Signal Corps by the Aeronutronic Div. of Ford Motor Co. Inputs to the ARTOC displays are generated by a Mobidic-B Army field computer system.

● **NTDS standardized**—Univac Div. of Sperry Rand Corp. was system integrator for the Navy Tactical Data System. The need for minimal engineering, production and logistics costs, coupled with the need for operational flexibility, dictated that a general-purpose, modular approach be applied to the design of NTDS hardware.

In addition to standardization of computers, the number of types of display equipment was minimized. Rather than use a separate display design for each function, multi-purpose consoles are used and, in case of console failure, any other console of that type can be used.

Rapid response is achieved through interrogation of the console 20 times per second. These data are transferred as a direct output from, and input to, the computer memory since input/output communication proceeds independently of the execution of the program.

All consoles have the ability to display raw radar video simultaneously with the regenerated computer data.

● **Navy trainer**—Typical of C&C displays used in tactical simulators is the Navy's 20C6 trainer at the Fleet Anti-Air Warfare Training Center, Dam Neck, Va.

The trainer, which was built by Honeywell, Inc., to simulate, in a typical shipboard environment, operational naval weapon designation equipment, includes five target selection and tracking consoles, two weapon assignment consoles and two director assignment consoles. Basic control element is an AN/UYK-1 digital computer.

Stimulated signals from a three-dimensional air search radar, miscellaneous fire control systems, missile launch systems and surface-to-air missiles can be monitored and controlled from an instructor's console and fed to trainees' consoles.

An analog "problem generator" provides target position information on up to 36 aircraft, as well as range and bearing of 12 other ships in the trainees' simulated task force.

The trainer also works in conjunction with a Navy Tactical Data System (NTDS) simulator at the Center. ■

Industry Cautious in Approach To Manned Spaceflight Systems

Scant human factors information exists despite considerable research; weight, reliability constraints hamper breakthroughs

WITH INCREASING EMPHASIS being given to man's role in spacecraft, the guidance of his activities is becoming one of the most challenging areas in display technology.

At the same time, however, the constraints put on such displays—low weight, high reliability, and reluctance to use untried techniques—are leading to a very cautious approach to the procurement of flight hardware. As a result, the spacecraft display is a field full of new ideas, but the hardware being developed is mostly conventional.

The main trend is to push conventional displays into as highly an integrated form as possible, without taking the major step of going to a single time-shared general-purpose display, and the consequent removal of the traditional maze of instruments.

Human factors play a crucial part in the design of a spacecraft display system, but in spite of a large amount of research, disappointingly little information is available to evaluate the qualities of different displays from a human factors standpoint. Chief reasons are the great difficulty in realistic simulation of spacecraft conditions, and absence of firm mission requirements.

As a result, one of the prime areas of interest in the Air Force *Manned Orbiting Laboratory* will probably be the evaluation of a number of redundant display systems in orbit. Only in this way can a comparison be obtained of the effectiveness of different display techniques under real spacecraft conditions.

Typical questions to be examined are whether such devices as predictor instruments, three-dimensional displays, and contact-analog displays have as much to contribute to crew performance as their advocates maintain.

● **Cathode tubes still best**—A study by the Aerospace Corp. for the Air Force concluded that it may be five years or more before spacecraft electroluminescent displays can compete with the performance of present cathode ray tube displays.

The same study concluded that the state of the art in three-dimensional displays does not allow their use in spacecraft, that diffculty in their interpretation precludes their use in extreme environments, and that, as yet, there was no demonstrated need for them.

Main positive conclusion of the study was that industry is capable of supplying the hardware for individual spacecraft displays of the cathode ray tube type.

Concern with the inadequacies of present display systems stems from camera recordings of pilot eye movement during flight, which reveal a great deal of scanning activity. Putting more information on one instrument, as in Honeywell's *Apollo* three-axis Flight Director Attitude Indicator, greatly reduces the scanning burden. The FDAI has, in fact nine instruments in one display.

● **Instrumentation advancement**—Another major step forward in conventional displays is the use of servo-driven vertical tape displays stacked side by side. The calibrated tape moves behind a fixed pointer, and, as the pointers are all in the same horizontal line, a very easy eye scan results. A display of this type is incorporated in a panel that is likely to be fitted to the *X-15* next spring.

This new *X-15* panel, developed by Lear Siegler Inc., for the Air Force, is probably the most advanced spacecraft panel currently scheduled for flight. It also includes a three-axis ball display and a CRT energy-management display.

Another type of instrumentation that involves a move toward greater integration is the head-up display, where the pilot sees the display projected into his field of view as he looks out of the cockpit. This is usually some form of analog display. Philco Corp.'s Autonetics Div. is actively investigating the potentialities of this type.

Another approach to reduce the visual load of the pilot is use of auditory signals to convey part of the flight information to him. Douglas Aircraft currently has a contract from NASA Flight Research Center to investigate the scalings and codings needed for this type of information, and to see what interactions take place between the sound and the vision channel.

● **Aiding the astronaut**—All these development paths recognize that the pilot's task is becoming increasingly more complex, and that this trend will probably continue in spacecraft.

It is this situation that has led to proposals for integrated displays using a general-purpose device such as a cathode ray tube. At any one time this shows those parameters of immediate interest to the pilot.

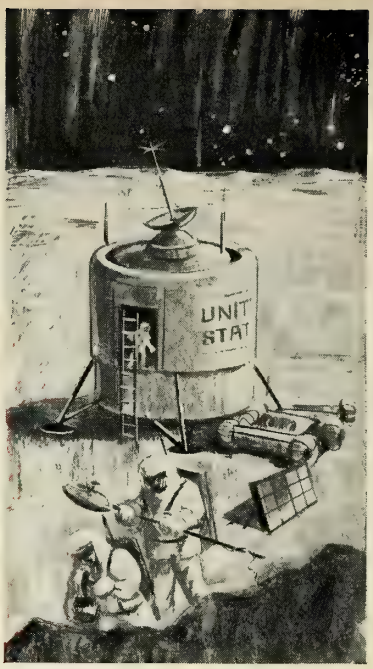
Order in which parameters are displayed is programmed for those parts of the mission that permit. During other parts, push-button selection of parameters is available. Flashing lights or automatic presentation of critical parameters (with manual override) would be used during emergencies.

Advantages of this display are that less equipment and panel space would be needed, with lower total weight and volume. Also, more parameters can be shown.

Integrated displays of this type have the advantage that they can be combined with predictor displays and contact-analog displays. Also infrared, radar, or television pictures can be superimposed when required. This capability may be particularly valuable in space missions.

For instance, in spacecraft rendezvous or planetary landing, it could provide the possibility of viewing the target via television or some other sensor system while at the same time having

beyond apollo—
the U.S. space program



4th annual NASA issue

november 30, 1964

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With major procurement for the Apollo manned lunar landing program now behind it, NASA is deep in the planning for new projects to expand man's knowledge of space, including such post-Apollo missions as the Lunar Logistic Supply System, Manned Orbital Research Laboratory, Extended Apollo, Project Voyager and Manned and Unmanned Planetary Probes. ComSat Corp., AEC and the Weather Bureau are drawing up plans for their growing participation in the peaceful use of space.

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orientation or command information in the same field of view.

An area of current interest to the Air Force is whether a general-purpose computer should be used to service all aspects of such displays or whether special-purpose display generators associated with the different information channels should be used.

● **Lear Siegler efforts**—Lear Siegler has been studying cockpit displays for the Air Force for a number of years. Latest system for an orbital vehicle uses a digital computer only for the generation of orbit parameters and the ground track display, and for calculations required for weapon checkout and deployment (a five-missile system). Other functions are displayed by servo-driven tape displays, dials and lights.

Lear's three-year program for design and fabrication of advanced military and space vehicle displays included display design for five *X-15* systems. The Mark V cockpit display, however, ran into funding difficulties because of Air Force/NASA tensions in the manned spacecraft area. The result is that some uncertainty hangs over the program, in spite of the fact that it has led to the development of some very fine hardware and promises to be extremely significant.

The display panel that is likely to go into the *X-15* No. 3 is an outgrowth of the Mark IV program for Wright-Patterson Air Force Base. The test program at NASA Flight Test Center, Edwards AFB, is concerned with an advanced integrated data system, which presently ends with use of the system in an F5D aircraft. It is inconceivable, however, that portions of this program and the hardware developed by Lear will not continue on into the *X-15* program.

● **Panel display details**—Main features of the new panel display, which still requires additional conventional instruments around its periphery, is the use of seven vertical tape displays located on either side of a three-axis ball display. Below this is the screen of an energy-management display for landing approach guidance.

The vertical tapes have been calibrated so that they remain legible at their maximum speed of movement past the fixed fiducial mark. Functions presented by the tapes are the ratio of dynamic pressure (q) predicted for perigee to the specified limiting q for the rocket plane, q in pounds per sq. ft., normal acceleration in gs, angle of attack, flight path angle (from an inertial reference), velocity in feet per second, and altitude. This is, in fact, basically a spacecraft display: flight-path angle, for example, is very important at orbital insertion.

The three-axis ball instrument indicates pitch, roll and heading (on ball), roll rate and angle of side slip. Cross pointers provide three different modes of operation to take account of the various flight regimes, including re-entry.

On the CRT of the energy-management display, a spot of light indicates the landing site, selected manually by a push button. If the spot is in front of a pair of parallel lines on the display, the pilot flies at maximum L/D, if it is behind the lines he flies at maximum coefficient of lift. He carries out these maneuvers until the spot is at the center of the display.

If the spot is in a certain area bounded by inverted V lines at the foot of the display, there is no single control setting that will take the pilot to the landing site: flying in a given direction and then turning to fly in the reverse direction is required.

● **Gemini and Apollo**—*Gemini* and *Apollo* displays are basically conventional. Lear three-axis indicators are used in *Gemini*. *Apollo* displays are state-of-the-art hardware with emphasis on instrument integration. Both *Surveyor* and the *X-15* will provide design inputs for the *Apollo* display.

Main parts of the *Apollo* display that have got into the hardware stage are the Honeywell Flight Director Attitude Indicator, the Attitude Set Gimbal Position Indicator, and the Velocity Change Indicator (M/R, Feb. 24, p. 26).

Primary reference in the Command Module is a three-gimbal-type aligned to a navigation base some 33 degrees from the principal body axis. This offset relates to the average re-entry offset center of gravity location and facilitates re-entry control of the Command Module lift vector. It also presents a special display requirement. Previous piloting experience relates to attitude measurements with respect to a vehicle principal axis.

The unconventional primary reference reflects in the display as an indicator gimbal sequence from inside to outside of pitch, yaw, and roll—to correspond to the Inertial Measuring Unit. The indicator's roll axis lies in a plane perpendicular to the viewing plane and inclined downward 16 degrees front-to-rear. This permits reading of both axes of interest via two indices.

The need to measure two precision axes offset from the familiar body axis will be a new experience for the *Apollo* astronauts, but it is a technique that has been mastered in simulator tests.

● **Command Module set**—*Apollo* Command Module displays are now fairly firm in design and will only be influenced by *Gemini* to the extent that experience reveals a need for improvement or modification in specific techniques. Servo-driven tape displays are not used in the Command Module because there is not enough power to drive them. A study is under way to see whether they can be used in the Lunar Excursion Module, with which there is a difficult scaling problem in display of velocity over ground.

The problem is that knowledge of horizontal velocity is needed both at values as high as 500 fps and also at the maximum horizontal landing speed of less than 10 fps. Such wide ranges can be handled by a suitably scaled tape, but give considerable difficulties on conventional instruments. Unfortunately, the power requirements of servo-driven tapes give an even greater problem in the LEM.

LEM displays are not firmed up yet, primarily because the complete system they serve is not yet firm, and the exact mechanization of this will influence display design heavily.

Surveyor results will influence LEM displays both through the systems constraints that the details of the lunar surface impose on the LEM and through the effect of lunar ambient lighting on display requirements. All design studies are now based on simulations of the lunar environment based on the best knowledge available.

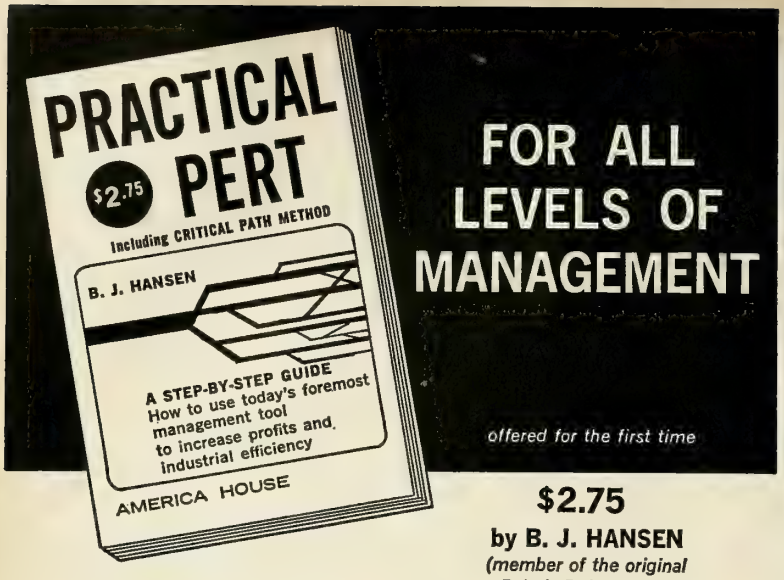
● **Mission differences**—Energy management problems differ between *Gemini* and *Apollo* because *Gemini* re-enters from circular orbit and the *Apollo* Command Module returns to the Earth's atmosphere at hyper-circular velocity and has to dissipate excess energy before performing re-entry from circular orbit.

Gemini does not have a CRT energy management system of the type to be flown in the *X-15*. Displays are limited to five-digit numerical outputs and meter movements. *Apollo* will have a system similar to that for the *X-15*, except that re-entry will primarily be automatic, with the crew performing a monitoring function.

NASA's Manned Spacecraft Center is watching the *X-15* work closely and officials say that flight of a similar CRT energy-management display in *Gemini* would be of considerable value in checking out such a system for re-entry from circular orbit. No plans for such an experiment have, however, been announced.

● **Honeywell simulation work**—Honeywell — subcontractor to North American Aviation, Inc., for *Apollo* stability and control instrumentation and displays—places considerable emphasis on mockup and simulator tests and has three *Apollo* mockups with analog computers, and a spacecraft simulator balanced on an air bearing.

The company has designed guidance and navigation displays for a general-purpose dynamic flight simulator which



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include a parameter read-in panel, a parameter readout panel, inertial status indicator, re-entry planning display, and an integrated map display, all serviced by a digital computer.

Honeywell's proposed approach to an integrated spacecraft-display is to use closed-circuit TV for camera images and electronically generated information.

Simulators will continue to play an important part in evaluating displays. General Dynamics / Astronautics is building a general line of simulators. Under development is a simulator with complete freedom of simulated movement and absence of gimbal restrictions.

GD/A is also carrying out human factors research concerned with vision in space. This relates to depth perception, color perception, and the effects of harsh lighting factors, which could greatly influence display requirements for rendezvous operations.

Predictor displays promise to eliminate some of the training an astronaut needs to find out how a spacecraft responds to controls. In effect, the display shows what will happen to the spacecraft if the astronaut follows a certain course of action, continuously changing the indication as he makes adjustments in response to the display.

Dunlap Associates have a NASA contract to study integrated displays in general and predictor instruments in particular for possible use in manned spacecraft navigation.

● **How they work**—Basically, these displays rely on the generation of predictive information by analog devices working in fast time, operating from sensing instruments, with the computation being carried out repetitively. The useful length of the prediction is a function of the size and frequency of unpredictable disturbances to the spacecraft and could amount to hours or days for spacecraft navigation.

For two or more variables, the best method of display seems to be by perspective coding on a CRT. A roadway on the screen represents vertical and horizontal position and becomes smaller (gains perspective) in the future time dimension. Curvature of the road predicts yaw, rise and fall predict pitch, and tilt predicts roll.

Where aspects of the mission are known in advance, it is possible to program such a display as a means of command. Because such systems call for computer capacity that might not be justifiable for this application alone, the same display might also be combined with a contact-analog display.

Uses suggested for predictive displays are for rendezvous during satellite inspection or re-supply, for re-entry, and general space navigation.

● **System genesis**—Contact-analog displays had their beginnings in the joint

Army-Navy Instrument Program (AN-IP) started about nine years ago. What is shown is a computed pictorial display, synthesized electronically and presented on a CRT. It is an integrated display in the sense that it combines flight information that would normally be presented on a number of conventional instruments.

United Aircraft Corp. has been working on such a system for helicopters and submarines, General Electric Co. is developing a system for use in flight simulators and high-performance aircraft, and Kaiser Aerospace and Electronics Corp. has developed a system for military and light commercial aircraft. All companies have expressed an interest in providing the same types of displays for spacecraft use.

The display is generally made up of two parts, each of which may be generated by a special-purpose digital computer. A ground plane pattern indicates roll and yaw according to its orientation. It is shown as a textured pattern that may vary according to the type of mission.

The Kaiser system shows a ground plane covered with ellipses that grow smaller as the horizon is approached. The GE system shows a textured pattern nested several times so that the smaller patterns fuse into the larger ones as altitude increases.

The second part of the display, superimposed on the ground plane, is the flight-path pattern, which might appear as a "roadway" or "tunnel" for the pilot to fly along, making it a command display. Input can either be from a flight controller or by manual crew insertion. Alternatively, a predictor display could be shown. The presentation in the GE system is a series of "tarstrips" placed along the flight path centerline; in the Kaiser system, it is a roadway.

• **Size, power restrictions**—These systems offer considerable flexibility in display, particularly as they can be combined in various ways with other pictorial sensor data. The main question that obscures their future, however, is how necessary they are in spacecraft, and when their size and power requirements will come within the limits of spacecraft technology.

As an alternative to producing a display on a fixed cathode ray tube in an instrument panel, there is the possibility of mounting a display device on an astronaut's helmet and superimposing the display on his field of view, by means of mirrors.

By suitable focusing of a virtual image, this can be seen when the pilot focuses his eyes at his near point, and seen through when he looks at more distant points. A 30-ounce display of this type has been investigated by the Office of Naval Research. ■

contracts

AWARDS

AIR FORCE

$10,165,446—**North American Aviation, Inc.,** Anaheim, Calif., for spare parts for *Minuteman* missile guidance control systems.

$2,826,415—**Union Carbide Corp.,** Linde Co., New York City, for propellant oxygen and nitrogen.

$2,800,000—**Hercules Powder Co.,** Wilmington, Del., for work on Stage III motors for *Minuteman.*

$1,600,000—**General Telephone & Electronics Corp.,** Automatic Electric Co., Northlake, Ill., to make communications switching gear.

$1,500,000—**General Dynamics Corp.,** San Diego, Calif., for continued work on Air Force boosters.

$1,500,000—**Boeing Co.,** Vandenberg AFB, Calif., for work on *Minuteman* systems.

$1,300,000—**Lockheed Aircraft Corp.,** Sunnyvale, Calif., for work on a classified space program.

$1,109,000—**General Tire & Rubber Co.,** Aerojet-General Corp., Akron, Ohio, for continued work on a *Titan II* propulsion system for the *Gemini* two-man space exploration program.

$300,000—**Weinschel Engineering,** Gaithersburg, Md., to supply the Model PCS-1B, Pulse Power Calibrator, a power measuring instrument.

$275,000—**Thiokol Chemical Corp.,** Reaction Motors Div., Denville, N.J., for a packaged storable liquid and solid propellant propulsion systems study.

$205,000—**Lear Siegler, Inc.,** Santa Monica, Calif., to provide automatic flight-control systems for the Q2C *Firebee* jet-powered target drone.

ARMY

$291,900—**Technical Operations, Inc.,** Beckman and Whirley, Inc., San Carlos, Calif., to produce safety destruct kits for the *Sergeant* ground-to-ground tactical missile.

$100,000—**Fairchild Camera and Instrument Corp.,** Electro-Metrics Corp. (Div.), Amsterdam, N.Y., for design, improvement and modification of radio frequency interference equipment.

$82,500—**General Electric Co.,** Cincinnati, for a ramjet study.

$62,203—**Electro-Optical Systems, Inc.,** Pasadena, Calif., for an airborne optical system.

$50,734—**Telecomputing Services, Inc.,** Panorama City, Calif., for film reading and data reduction, airborne *TOW/Shillelagh* feasibility program.

$44,425—**Detweiler Bros., Inc.,** Twin Falls, Idaho, for rocket motor quench system.

NAVY

$22,018,000—**Goodyear Tire & Rubber Co.,** Goodyear Aerospace Corp., Akron, Ohio, for *Subroc* missiles.

$7,232,040—**Sperry Rand Corp.,** Ford Instrument Co. (Div.), Long Island City, N.Y., for work on fire-control computers for *Terrier* and *Tartar* missiles.

$6,500,000—**Westinghouse Electric Corp.,** Baltimore, to continue production of the Mark 45 torpedo.

$5,674,000—**Pennsylvania State University,** Ordnance Research Lab., University Park, Pa., for R&D in the field of naval weapons and in related fields including academic programs, acoustics and signal processing, engineering, hydromechanics, missile systems, weapons development and consultation.

$1,840,000—**Interstate Electronics,** Anaheim, Calif., for modification of four sets of test instrumentation for use with *Polaris* submarines.

$100,000—**Bendix Corp.,** Mishawaka Div., Mishawaka, Ind., to conduct engineering study of an alternate guidance section for standard missile type 1.

NASA

$4,614,086—**TRW/Space Technology Labs,** Redondo Beach, Calif., for mission trajectory control programs.

$2,481,399—**Allis-Chalmers,** Research Div., Milwaukee, Wis., to build fuel cell electrical power systems.

$2,405,211—**General Electric Co.,** Oklahoma City, Okla., for a range and range rate system.

$588,890—**General Electric Co.,** Mississippi Test Support Operation, Huntsville, Ala., for mobile instrumentation units to be delivered to Miss. Test Facility.

$264,880—**Spacelabs, Inc.,** Van Nuys, Calif., to produce physiological signal conditioners for the *Gemini* program.

$200,000—**General Electric,** Missile and Space Div., Philadelphia, for continuation of magneto gas dynamic power generation study.

$143,473—**TRW/Space Technology Labs,** Redondo Beach, Calif., for development of a 93-lb. ablatively cooled, pulse-modulated bipropellant rocket engine.

$120,959—**Collins Radio Co.,** Dallas, for installation of ground equipment at an antenna facility.

$99,000—**Radio Corp. of America,** Princeton, N.J., for weather data relay system breadboard.

$91,819—**USAF Logistic Command,** Middletown, Pa., for liquid hydrogen; also $71,836 for propellants.

$98,800—**Emerson Electric Co.,** Electronics and Space Div., St. Louis, for development of life-support umbilicals.

$90,398—**Cornell Aeronautical Lab.,** Buffalo, N.Y., for a pulsed laser ion generator study.

$89,950—**Rice University,** Houston, for design standards for a magnetically oriented spacecraft and construction of an optimized mechanical model.

$66,750—**Texas Instruments, Inc.,** Dallas, for quantitative methods for LEM landing site selection.

$61,580—**Westinghouse Electric Corp.,** Aerospace Electrical Div., Lima, Ohio, for design, development, fabrication, test and delivery of an experimental model of a power converter for ion thrusters.

$60,264—**Union Carbide Corp.,** Parma Research Center, Parma, Ohio, for program to improve fuel cell performance through pulsing techniques.

$51,358—**Radiation Applications, Inc.,** Long Island City, N.Y., for an improved water reclamation system for manned space vehicles.

$48,000—**Lockheed Missiles & Space Corp.,** Sunnyvale, Calif., for a parametric study of heat rejection concepts.

INDUSTRY

$17,000,000—**Sperry Rand Corp.,** Univac Div., Washington, D.C., from **Bell Telephone Laboratories, Inc.,** Whippany, N.J., for design and development of multi-processor computers and computer memories for the *Nike-X* data-processing subsystems.

$941,000—**Watkins-Johnson Co.,** Palo Alto, Calif., from **Electronic Specialty Co.,** Los Angeles, to design and manufacture a family of magnetically tunable YIG (yttrium iron garnet) filters designed to operate over slightly more than an octave in five frequency bands.

$600,000—**Electronic Communications, Inc.,** St. Petersburg, Fla., from **Boeing Co.,** Aerospace Div., Seattle, to design and develop special-purpose communication equipment for the *Minuteman* missile program.

$175,250—**Allis-Chalmers,** Milwaukee, Wis., from **Northrop Corp.,** Nortronics Div., Needham Heights, Mass., to fabricate the steel arm for a rotating test facility that will simulate launch phase conditions of a space flight.

$150,000—**United Aerotest Laboratories Inc.,** Deer Park, N.Y., from **Pall Corp.,** Aircraft Porous Media, Inc., Glen Cove, N.Y., to cover performance and reliability testing on the filter system for the descent stage of the Lunar Excursion Module propellant system.

SENIOR RESEARCH SCIENTISTS

Ph.D. level in Aerophysics, Aeronautics, Gas Dynamics or equivalent fields with achievement records in publications and/or patents for research in such fields as: Transonic Airfoils, Shock-Boundary Layer Interactions, Interference Effects, Ground Effects, Unsteady Transonic Flow, Gas-Surface-Interactions, and Transport Problems in Hypersonic Flow.

These positions are directly connected with a challenging research program constituting one of the key activities in the new Research Center now under construction at the Lockheed-Georgia Company, Marietta, Georgia.

Send resume, in confidence, to: Dr. C. H. von Kenschitzki, Associate Director of Research, Lockheed-Georgia Company, 834 West Peachtree Street, Atlanta, Georgia 30308, Dept. OO-77.

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names in the news



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DYER

Charles H. Berry: Named vice president of General Precision, Inc., Tarrytown, N.Y., and assigned corporate manager of the firm's Washington, D.C., office.

Robert S. Ames: Appointed vice president of manufacturing of Bell Aerosystems Co., Buffalo, N.Y., a division of Bell Aerospace Corp.

Donald M. Miller: Named president of the Airborne Instruments Laboratory Div., Cutler-Hammer, Inc., Milwaukee, Wis. **John N. Dyer:** Promoted to executive vice president for research, engineering and advanced planning for AIL Div.

Irving Cohen: Elected vice president-command and control systems of Informatics, Inc., Sherman Oaks, Calif.

Ernest Stern: To provide direction for study program of a satellite-borne ocean surveillance system for U.S. Navy as Director, MOL Ocean Surveillance Study, TRW Space Technology Laboratories, Redondo Beach, Calif.

Timothy L. Hanley: Appointed director of General Motors' AC Spark Plug Div. Research and Development Lab, Boston.

Philip J. Maher, Jr.: Appointed executive vice president of The Firewel Co., Inc., Buffalo, N.Y.

Robert N. Tomb: Joined General Precision, Inc., Tarrytown, N.Y., as manager, plans and requirements, NASA.

Glen G. Reed: Elected a director of Dorr-Oliver Inc., Stamford, Conn. He is also vice president of the international division of Dorr-Oliver.

George E. Bein: To head the first regional office of General Kinetics Inc., in Los Angeles. His responsibilities will include applications engineering and customer liaison.

Chandler W. Jones: Appointed manager of Block Engineering, Inc., Cambridge, Mass., Field Service Div. Also named to a new managerial post was **Alexander S. Zachor,** who has been appointed manager of Block's new Data Reduction and Analysis Div.

W. L. Vergason: Added to the public information staff of Radiation Inc., Melbourne, Fla. He was formerly market development manager of Sperry Electronic Tube Div., Gainesville, Fla.

John F. Straubel: Formerly public relations and advertising manager for Hiller Aircraft Co., Inc., named director of communications for Fairchild Stratos Corp., Washington, D.C.

Flavio S. C. Branco: Appointed to the new position of chief engineer at Fairchild Camera and Instrument Corp.'s Winston Research Corp., Los Angeles. He will be responsible for the overall technical engineering, design and evaluation of all engineering projects for Winston.

Richard P. Turner: Appointed national manager of Magnaflux Corporation's thirteen Materials Testing Labs. Magaflux is in Chicago.

Marvin B. Ruffin: Appointed to the posts of executive vice president and corporate general manager of Model Engineering and Manufacturing Corp., (MEMCOR), Chicago.

Rulon G. Shelley: Appointed manager of Raytheon Co.'s Santa Barbara, Calif., operation, a unit of the firm's Space and Information Systems Div.

K. Martin Stevenson: Appointed director of General Motors AC Spark Plug Div. Research and Development Lab, El Segundo, Calif. He was head of AC's research and development facility at Boston prior to the appointment.

M. L. Lesser: Appointed director of systems technology of IBM Corp., Armonk, N.Y. He was formerly director of technical planning on the same staff. **Dr. Munro K. Haynes:** Promoted to director of technology and engineering planning of IBM Corp. He was formerly manager of the technical advisory staff in IBM's Research Div.

C. R. Olsen: Appointed to the newly created post of director of product assurance for Whittaker Corp., Controls and Guidance Div., Chatsworth, Calif. He was formerly with Raytheon Co. where he was active in the *Polaris and Apollo* programs.

William F. Frankart: Appointed chief engineer of Gonset, Inc., Altec Lansing Corp., Anaheim, Calif., a subsidiary of Ling-Temco-Vought, Inc. He is a specialist in two-way radio communication.

—when and where—

OCTOBER

1964 Annual Meeting of the American Documentation Institute, Philadelphia, Oct. 4-8.

Second Annual Research Management Program, sponsored by the Battelle Memorial Institute and Ohio University, Battelle Memorial Institute, Columbus, Ohio, Oct. 4-16.

National Symposium on Space Electronics and Telemetry, sponsored by the IEEE, Dunes Hotel, Las Vegas, Nev., Oct. 4-9.

Third Annual USAF Contract Aerospace Services Symposium, sponsored by the National Aerospace Services Assoc., Dayton Biltmore, Dayton, Ohio, Oct. 5.

10th National Communications Symposium, sponsored by the IEEE, Utica, N.Y., Oct. 5-7.

10th Annual Army Human Factors Research and Development Conference, Ft. Rucker, Ala., Oct. 5-8.

Parameters of Information Science, sponsored by AFOSR and the American Documentation Institute, Sheraton Hotel, Philadelphia, Oct. 5-8.

National Aeronautic and Space Engineering and Manufacturing Meeting, sponsored by the Society of Automotive Engineers, Ambassador Hotel, Los Angeles, Oct. 5-9.

Seminar on Quantum Mechanics, sponsored by the American Institute of Physics and the National Association of Science Writers, Inc., Hotel Statler-Hilton, New York City, Oct. 6.

International Space Electronics Symposium, sponsored by the IEEE Space Electronics and Telemetry Group, Dunes Hotel, Las Vegas, Nev., Oct. 6-9.

Electronic Information Handling Conference, sponsored by the University of Pittsburgh, Goodyear Aerospace Corp. and Western Michigan University, Hotel Webster Hall, Pittsburgh, Oct. 7-9.

Galileo Quadricentennial, sponsored by the University of Rochester and the National Science Foundation, University of Rochester, Rochester, N.Y., Oct. 8-9.

Society of Plastics Engineers, Inc., Regional Technical Conference, Cleveland, Oct. 8-9.

Refractories Division of the American Ceramics Society Fall Meeting, Cavalier Hotel, Virginia Beach, Va., Oct. 8-10.

Electrochemical Society Meeting, Sheraton-Park Hotel, Washington, D.C., Oct. 11-15.

Flight Mechanics and Entry Technology Meeting, sponsored by the AIAA and NASA, Convention Center, Williamsburg., Va., and Langley Field, Va., (Meeting at Langley is classified), Oct. 12-13.

Second Aerospace Nuclear Propulsion Conference (partly classified), sponsored by the American Nuclear Society, AIAA, Atomic Energy Commission, and NASA, Naval Postgraduate School, Monterey, Calif., Oct. 12-15.

Symposium on Dosimetry in High Level Exposure, International Atomic Energy Agency, Vienna, Austria, Oct. 12-16.

Second Guidance Test Symposium, Sponsored by the Air Force Missile Development Center, Holloman AFB, N.M., Oct. 13-14.

National Electronics Conference, sponsored by the IEEE, McCormick Place, Chicago, Oct. 19-21.

East Coast Conference on Aerospace and Navigational Electronics, sponsored by the IEEE, Baltimore, Md., Oct. 21-23.

11th Symposium on Nuclear Science, sponsored by the IEEE and Air Force Office of Scientific Research, Philadelphia, Oct. 27-29.

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How To Play Unpolitics

WE HAVE BEEN MOST INTERESTED in the vagaries of the Dept. of Defense in regard to the series of advanced planning briefings for industry.

This series originally was scheduled as a classified program to fully brief the industry on the latest and most up-to-date DOD thinking about the nation's defense needs.

With Secretary of Defense McNamara and his deputies urging the industry to adapt its advanced technology to tactical problems—in a significant shift from previous emphasis on strategic weapons—the need for such classified sessions was apparent.

The Deputy Director for Defense Research and Engineering, Dr. Eugene Fubini, and others had been pleading for industry help on a number of problems.

When the series was proposed, industry acceptance was overwhelming. Overwhelming, in this instance, is a word carefully chosen. So many members of industry—with security clearances and an obvious need to know—indicated their intention of attending that DOD decided to cancel the briefings.

We find it extremely difficult to follow this reasoning—but we must admit this is not the first time we have had this trouble with the Defense Dept. approach to logic. Presumably, if only a few persons in industry had indicated an interest, the classified briefings could have been held and been regarded as a roaring success.

Since, however, there was such an obvious thirst for knowledge in the industry, it was regarded as imprudent to do anything other than fill in the well.

The official reason given for the cancellation was that there did not exist in Washington a secure auditorium of sufficient size to accommodate all those who indicated an intention to attend.

There exist in Washington several auditoriums both sizeable and secure. Much more secure, we might point out, than the Statler-Hilton Hotel in downtown Los Angeles, where DOD last week saw no objection to classified briefings on liquid propulsion for some 700 members of industry and government.

Obviously, it would have been impossible to accommodate all those who wished to attend the proposed DOD seminar in a single briefing in Washington. Equally obvious, a series of identical classified briefings for industry could have been held in Washington or in a number of centers around the country.

Now, if we may be permitted the risky privilege of speculating about DOD thinking in this matter, the reasoning behind the cancellation must have been that a considerable security risk was involved in briefing so many members of industry simultaneously on classified programs.

"They all have security clearances and it's safe to brief them one at a time on classified subjects," someone must have said, "but to brief thousands of them all at once is a great security risk."

It may simply have been, of course, that the planned series of classified defense briefings conflicted with scheduled symposia on disarmament and diversification. We will never know.

Whatever the reason, it left Dr. Fubini and others who still felt that industry might have some small role to play in the defense of the nation in a somewhat awkward situation. If the military-industry partnership were to continue to function, a means would have to be found to give industry a clue as to just what Secretary McNamara had in mind for the future.

The answer was not long in the seeking. Planning was shifted to a series of declassified briefings. It was apparent from the first that this no-confidence decision would mean sessions of significantly less value to industry. Nevertheless, any hint as to Defense Dept. planning was welcome.

When it was announced that a series of such briefings would be sponsored by the National Security Industrial Association, with Assistant Secretary of Defense (Public Affairs) Arthur Sylvester coordinating DOD participation, industry response again was overwhelming.

It was apparent that industry felt desperately in need of DOD guidance in planning its participation in future weapons development.

First of these sessions was set for New York City on Sept. 17 and 18, to be followed by briefings in Chicago, Dallas and Los Angeles. Two weeks prior to the first day of the opening meeting in New York, reservations for that session alone totaled 1,267.

Then, once again, the axe fell. The advanced planning briefings were postponed until after the elections, with a new date set in February, 1965. Reason? The briefings might be construed as partisan political activity. Inside word is that the decision originated in the White House.

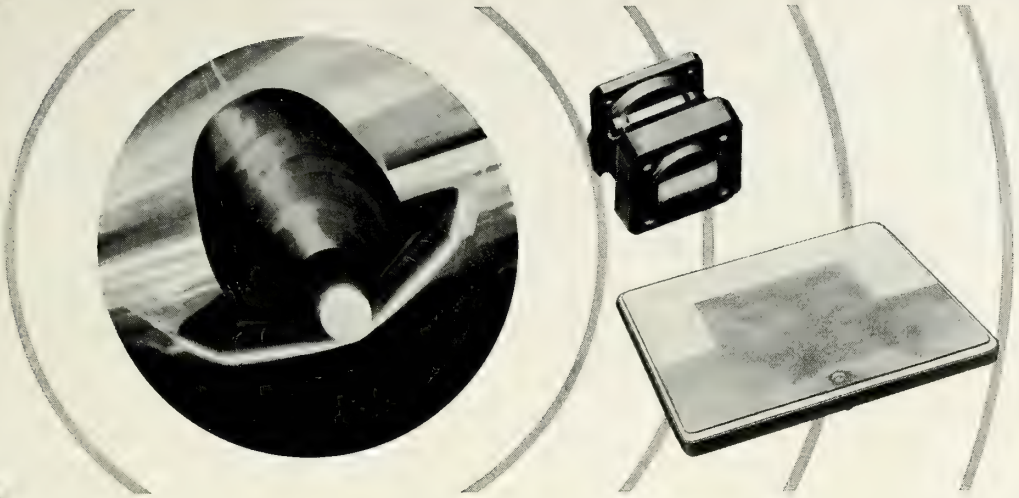
THIS DECISION, by an Administration so obviously willing to engage the Dept. of Defense in partisan politics, is sheer hypocrisy. If this policy were being followed right down the line, we would be the first to applaud the decision. But President Johnson's willingness to involve DOD in the campaign is apparent. This includes Secretary McNamara's appearance before the resolutions committee of the Democratic National Convention. It includes unveiling of a number of items of military hardware. To assert that Sen. Goldwater is attacking Administration military policies is no defense. The incumbents have more responsibility in this area than the challenger. The situation has led columnist Arthur Krock of the *New York Times* to comment:

"With this involvement came the end of the Department's service to (First Secretary of Defense James) Forrestal's principle . . . that, since it is accountable for the military security of the entire population of the United States, direct participation by the Department in the interest of one side of a partisan political issue is a gross impropriety and an impairment of its function."

Having forsaken the principle, the Administration has no excuse for cancelling this badly-needed series of briefings. In such a light, the cancellation itself appears a desperate effort to shore up politically a position already abandoned. The briefings were too important for such a partisan decision.

William J. Coughlin

Employment opportunities for those who would apply electronics as an interdiciplinary science



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In programs such as this, McDonnell Electronic Equipment Division engineers are demonstrating the effectiveness of their approach to the application of electronics as an interdisciplinary science. The hostility of the space environment places severe tests on electronic equipment and systems. Weight and size restrictions remain paramount while resistance to space radiation, g-loads and temperature variations become more important as the missions grow more complex.

While the application of electronics in the space environment is a major program at McDonnell, systems and equipment under active development virtually blanket the environmental spectrums of earth, sea, and atmosphere as well as space. Engineers enjoy the advantage of clearly defined and supported corporate objectives that lead projects out of the laboratories and into application. Well-equipped engineering laboratories and manufacturing facilities combined with continued corporate reinvestment aimed at technological growth provide the environment necessary for professional growth. **Current requirements exist for electronic engineers capable of systems planning, simulation and integration for aircraft, spacecraft and missiles as well as advanced technological contributions in the fields of plasma physics, information theory, laser technology and microwave techniques. Openings at all levels exist in the fields of Guidance & Control, Space Communications, Radar & Electro-Optics, Plasma Physics, Reconnaissance Sensors, ECM & Electronic Warfare, and System Integration & Testing.**

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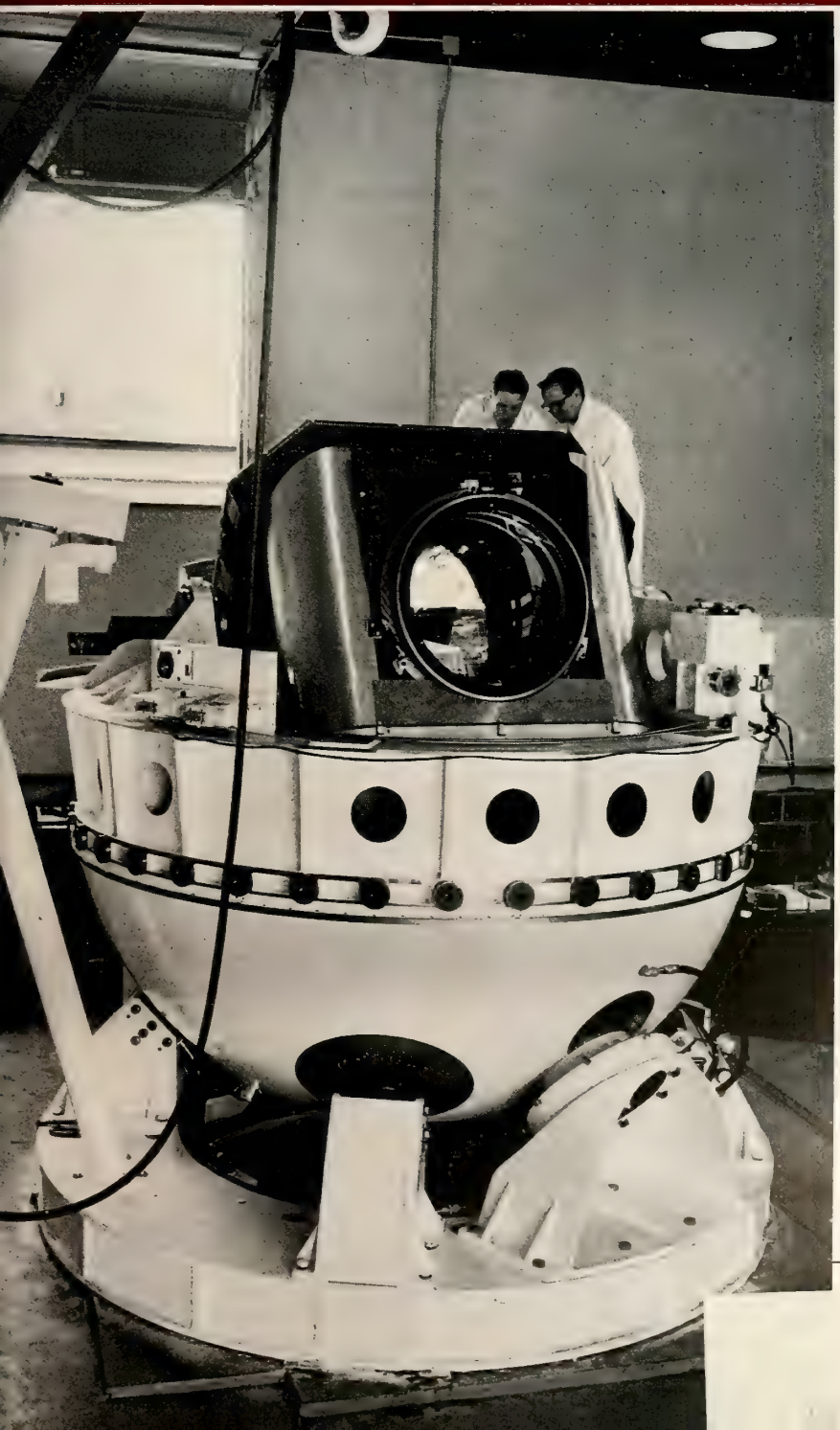
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OCTOBER 12, 196

missiles and rockets

THE WEEKLY OF SPACE SYSTEMS ENGINEERING

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AF Studies New Mobile Missile

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Systems Analysts & Preliminary Design Engineers for Advanced Space Guidance & Control Systems

Rapid expansion of space contracts, projects and studies at the HUGHES Aerospace Divisions in Southern California has created unusual opportunites for several qualified Engineers, Physicists and Mathematicians for Advanced Space Systems assignments.

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Control System Synthesis

To analyze control system requirements for various space vehicles; establish subsystem and component requirements; conduct system preliminary design; study measurement instrumentation and torque-producing equipment.

Simulation

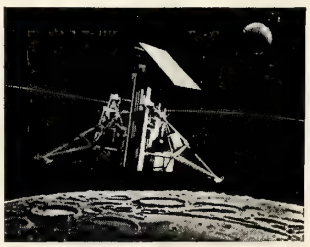
To plan digital simulation for studies related to earth orbital, trans-lunar, interplanetary and re-entry trajectories; analog simulation of rendezvous guidance and control systems.

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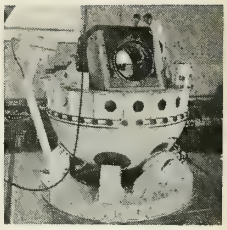
Printed at Judd & Detweiler, Inc., Washington, D.C. Second class postage paid at Washington, D.C.

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THE COVER



Technicians at Perkin-Elmer Corp., Norwalk, Conn., inspect high-performance telescope in POSS optical satellite tracking system built under RCA contract for Air Force's Spacetrack network. System has been shipped to Cloudcroft, N.M., where it will be operational next year.

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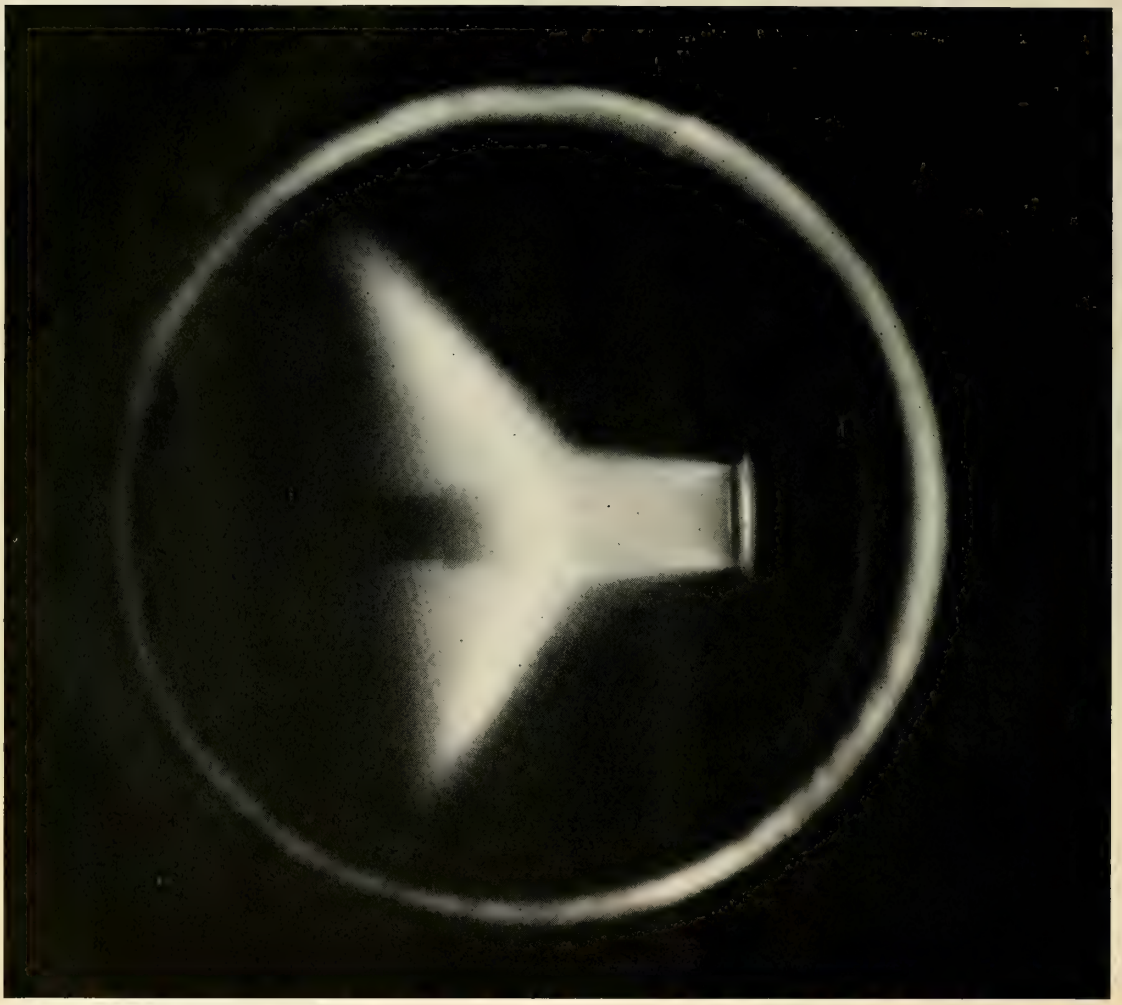
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This view inside BFG's Plasma Arc Tunnel shows an ablative material sample under test. Gas velocities up to Mach 3, thermal capacity up to 25,000 BTU/lb. help in evaluating improved materials for heat shields and other critical parts.

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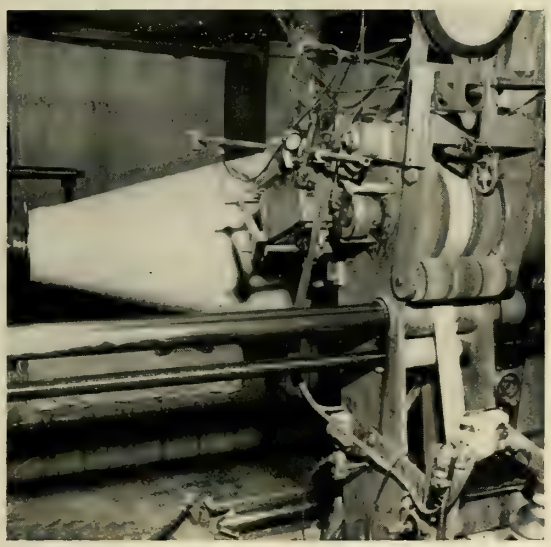
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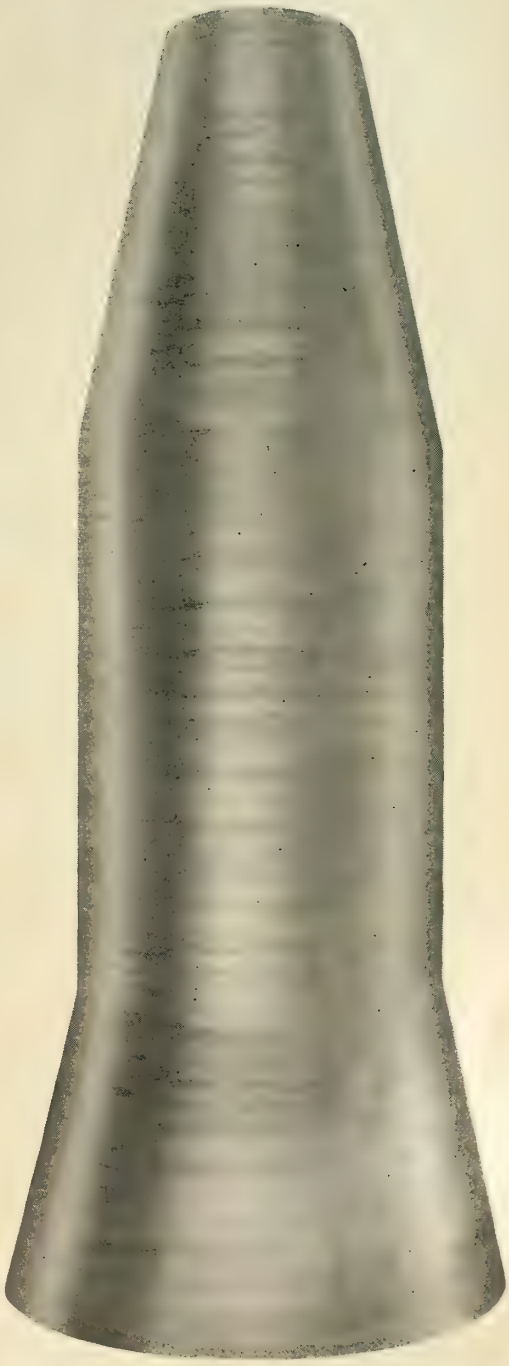
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COLUMBUS DIVISION NORTH AMERICAN AVIATION

letters

'The Briefing'

To the Editor:

I'd like to compliment you on your editorial in the Sept. 28 M/R ("The Briefing")

It's factual, hard-hitting, humorous—and I wish I'd written it myself. What more can I say?

I have never before written anybody complimenting him on an editorial.

Malcolm W. Boyd
Palo Alto, Calif.

To the Editor:

Your (Sept. 28) editorial outdid them all. I think you missed your calling—you really should write a sophisticated satire for an outstanding Broadway success! Seriously, I think you hit the nail on the head and got the message across to the reader.

Keep up the good work.

W. J. Hesse
Vought Aeronautics Div.
Ling-Temco-Vought, Inc.
Dallas

To the Editor:

Reference your Sept. 28 editorial.

An editor who, at this late date, is not familiar enough with the policies of the national Presidential candidates to know that Sen. Barry Goldwater believes this nation cannot survive without *heavy reliance on missiles* and that our defense system also needs the versatility offered by a strong combination of missiles, aircraft and naval vessels, cannot be considered a competent editor.

Mrs. W. F. Davies
Lompoc, Calif.

To the Editor:

Congratulations.

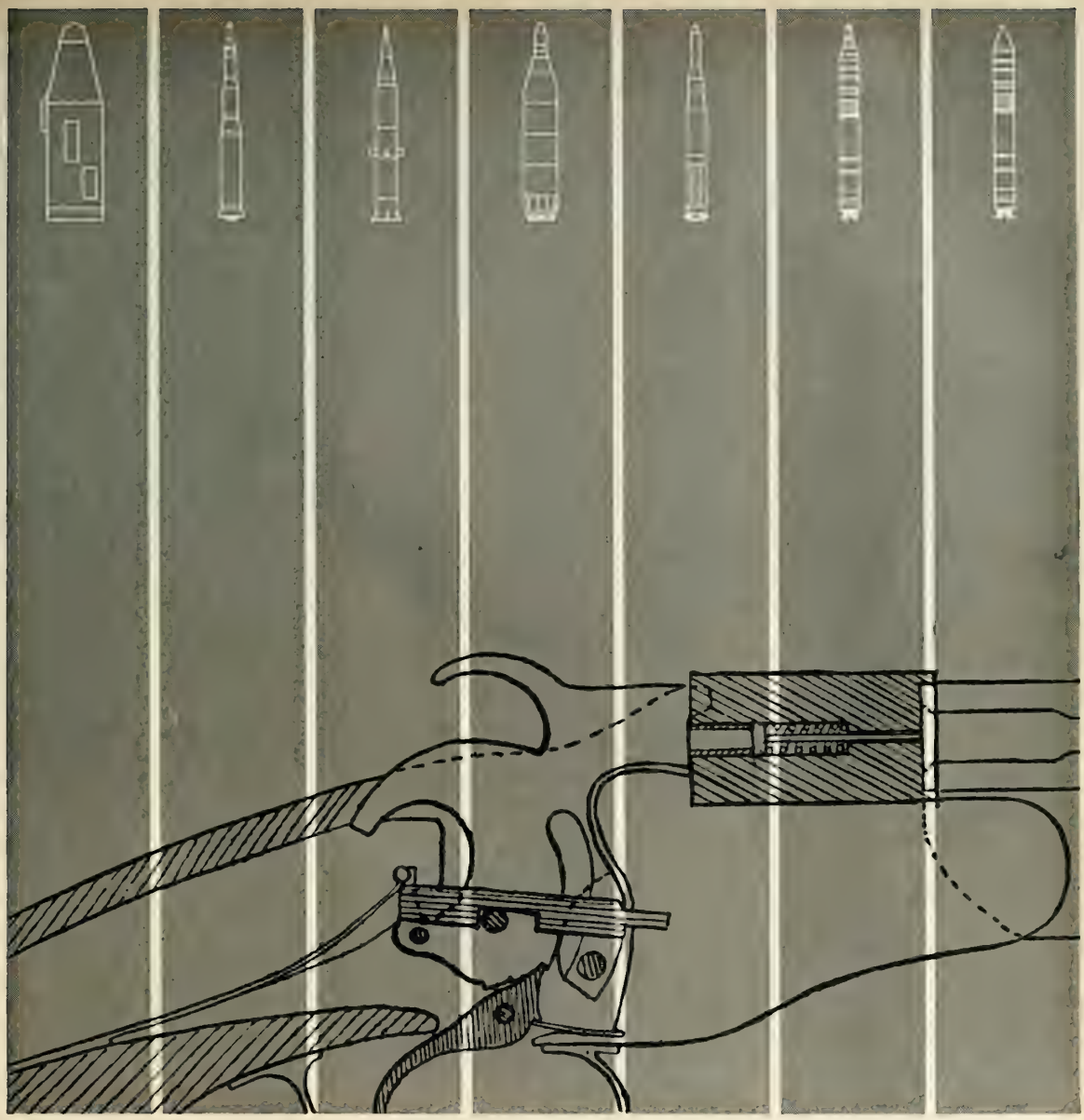
M. G. Sturgis
Santa Ana, Calif.

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REPRINTS of the entire Special Report on Anti-Submarine Warfare published in the September 21 MISSILES AND ROCKETS *may be obtained from:*

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The Countdown

WASHINGTON

TMRBM Contracts = Minuteman II

If the *Transportable Medium Range Ballistic Missile* (see p. 16) is approved for development, the contractor structure probably will be essentially the same as that of the *Minuteman II* program. Boeing will be missile assembly and checkout contractor, Aerojet will have the first stage of the *TMRBM* and Hercules the second stage. Autonetics will supply the guidance system. A new addition will be Bunker-Ramo, which is responsible for the command and control system of *MMRBM*. Re-entry vehicle and transporter-launcher contractors are less evident. Aeronutronic and Goodyear had these portions of the *MMRBM*, but whether they would get similar responsibilities for *TMRBM* is questionable.

STINGS Headed for Junk Pile?

When *MMRBM* was cancelled and its stellar inertial guidance system (STINGS) continued, it was widely assumed that the latter had a bright future. However, a DOD official tells COUNTDOWN the program is being continued only as "an advanced development" to demonstrate the feasibility of such a system. He adds that "there are no plans to fully develop STINGS unless we can find applications for it." One application already mentioned by the Air Force is precision orbit and recovery. Meanwhile, the STAFF program continues to slip, and the Air Force says only that "schedules are being constantly reviewed."

Reds Snarl Space Medicine Cooperation . . .

U.S. and Soviet negotiators will try at a meeting next month to salvage the space-cooperation agreement to exchange data on space medicine. Russians backed out of the pact under a provision that allows each nation a 90-day escape hatch after tentative agreement has been reached. They want scientists from both nations to write on different subjects. U.S. position—and the basis for the tentative agreement—was that a writer from each nation would produce a book on specific space-medical programs and that these would then be exchanged.

. . . And Take New Anti-ComSat Tack

Russia continues to attack the Communications Satellite Corp., but less harshly than it did last month at the IAF meeting in Warsaw. At last week's opening session of the legal subcommittee of the UN's Committee on Peaceful Uses of Outer Space, the Soviets, oddly enough, attacked ComSat on grounds easy for the U.S. to rebut. The Russian delegate said in essence that international systems should be agreed to between governments and not "at the level of private capitalist enterprises." The U.S. representative reminded the subcommittee that the principal international agreement on ComSat was signed by 14 governments—after which a supplementary pact was signed by "communications entities designated by governments."

Three Bostonians Get ERC Assignments

NASA has picked three men—all Boston residents—for top-level posts at the new Electronics Research Center. James B. Cahalane, formerly an assistant director of the space agency's Northeastern Office, has become chief of procurement. James T. Dennison has been appointed director of technology utilization, effective Nov. 1. And Walter J. Stuart, previously chief of administrative services at the Army's Watertown (Mass.) Arsenal, has been chosen for the same job at ERC.

MILA To Go Under Wraps

NASA will close most of its 88,000-acre Merritt Island Launch Area to the public on Nov. 1. Dr. Kurt Debus, Kennedy Space Center director, says the move has been planned for some time and will ensure safety of the public and protection of government property. Provisions are being made to badge NASA and contractor personnel—and the owners of citrus groves still located within the launch area.

Titan III-A Foregathers at Cape

First stage of the second *Titan III-A* is due to arrive at Cape Kennedy this week. The second stage and Transtage are expected to follow shortly.

Mariners Readied for Early November

Tentative launch dates for *Mariner* shots to Mars have been set for Nov. 4 and 6, although if the first vehicle appears to be on a good course the second will be held for launch near the end of the window. If the first shot is not good, the second spacecraft will be launched on Nov. 6. *Atlas-Agena* vehicles and spacecraft are now in place on Complexes 12 and 13 of Cape Kennedy.

INDUSTRY

Hughes Chosen for New Surveyor Study

Hughes Aircraft Co. has been selected by NASA to study possible use of the *Surveyor* spacecraft as a lunar probe. *Surveyor* would be ejected from an *Apollo* spacecraft to the Moon's surface while the manned vehicle was in lunar orbit. Six-month investigation will be worth about $100,000.

AF Developing Air-Recoverable Rocket

Air Force Special Weapons Center has asked industry for proposals to develop an air-launched, air-recoverable rocket. Presumably such a system would be launched into a radioactive cloud to collect samples, then recovered by the mother aircraft in a less hazardous area.

Advanced Military Comsat To Be Studied

Contracts are likely to be let to industry within the next few months for studies of an advanced, follow-on military communications satellite system, Thomas Rogers, assistant DDR&E director, told the International Space Electronics Symposium in Las Vegas. Primary emphasis will be placed on longer satellite lifetimes—on the order of at least three years and preferably five.

INTERNATIONAL

ESRO Preparing Telemetry Purchase

A large order for rocket-borne telemetry soon will be placed by the European Space Research Organization (ESRO). Firms with European outlets will be preferred. Total ESRO budget for 1964-67 is $72 million. ESRO also is negotiating for satellite tracking stations at Fairbanks, Alaska, and in Belgium, the Falkland Islands and Spitzbergen, Norway, it was disclosed at the International Space Electronics Symposium.

Dutch Building Telescope Network

The Netherlands plans to construct a new synthesis radio telescope network at an estimated cost of $4.2 million. It will consist of ten 82-ft.-dia. telescopes located at 492-ft. intervals in the Dutch province of Drenthe.

DOD Comsat Plans Rapped

A Congressional committee in a caustic report has told the Department of Defense that it should drop plans to launch the first military communications satellites on the experimental *Titan III-C*, and start work immediately on a program using the *Atlas-Agena*.

The House Military Operations subcommittee headed by Rep. Chet Holifield (D-Calif.) also recommended that DOD use the three *Titan III* vehicles that are available to the program for launching synchronous satellites instead of the medium-altitude random satellites.

If DOD does not elect to use *Titan III* to launch to the synchronous altitude, the committee said, the alternative approach would be to procure communications satellites that could be used on both *Atlas-Agena* and *Titan III*. Placing one in 19,000-mi. equational orbit and one at 6,000-mi. polar orbit would minimize risk and give better coverage, the report stated.

The entire handling of the DOD-ComSat Corp. affair was sharply rapped. The committee said it was not the intent of Congress that such budget restraints be imposed by the Secretary of Defense on the communications satellite program. "Had the Department moved ahead according to plans and policies laid down two years ago and approved by the Joint Chiefs of Staff, a system could have been operating now," the group said.

Re-entry Vehicle Flown

An experimental re-entry vehicle carrying 25 experiments was launched Oct. 2 aboard an Air Force *Titan II* missile from Vandenberg AFB, Calif. The General Electric Mark 6 re-entry vehicle was the second or third such re-entry probe that has been flown as part of the Advanced Research Projects Agency (ARPA) Defender program. More flights of the re-entry probe are planned.

Among the experiments carried were Langmuir probes to measure electrical properties of the re-entry plasma, magnetic conductance coils to measure conductivity of the plasma, an impedance probe to transmit an electromagnetic wave into the plasma to measure electron density and collision frequency, a rocking grating spectrometer to obtain information on the gaseous products of ablation, a wake angle scanner to measure amount and distribution of infrared energy in the re-entry wake, and an electrostatic field meter to measure the electric potential of the vehicle during flight. Quartz windows in the skin of the re-entry vehicle allowed instruments to view the plasma sheath.

The *Titan II* flight itself was part of an operational SAC launch test.

MMRBM Cancellation Hit

The State Dept. has been blamed for the demise of the Air Force's *Mobile Medium-Range Ballistic Missile (MMRBM)*.

In an Oct. 7 statement prepared for insertion in the *Congressional Record*, Rep. Gerald R. Ford (R-Mich.) charged that the State Dept's preference for a Multilateral Force (MLF) in Europe and not lack of Congressional support caused *MMRBM's* cancellation.

Ford, chairman of his party's House Conference Committee, is ranking minority member on the Defense Appropriations subcommittee. He said State pressured the Defense Dept. to drop the *MMRBM* program and refused to actively pursue negotiations for *MMRBM* deployment rights on foreign soil because it favored the MLF for reasons of its own.

"State . . . clearly indicated that they prefer the MLF to be used in the defense of Europe particularly and in other parts of the world where this type of weapons system *(MMRBM)* would be required," Ford said.

"In their justifications of the MLF, one can clearly see the arguments they would use for discouraging the *MMRBM* concept. It is reasonable therefore to expect that if the *MMRBM* ever becomes operational, it would be more difficult to proceed with the MLF concept." (See related story, p. 16).

Saturn Modification Award Let

NASA has awarded two contract modifications totaling $14,754,418 to Boeing Co.'s Aerospace Div. for work on the *Saturn V* first stage.

The first award, worth $11,836,000, calls for Boeing to conduct a structural static load testing program on the S-IC. The second contract, valued at $2,918,418, is for design, development and manufacture of components for the S-IC stage umbilical connection and related hardware.

'Snapshot' Set for Spring

An Electro-Optical Systems cesium-ion engine powered by SNAP-10A nuclear generator will be orbited by the Air Force next spring. The payload will be launched by an *Atlas-Agena*.

Programmed for a flight time of 90 days, the engine will develop a total thrust of 10 millipounds and will be cycled through at least 100 on/off operations. The engine uses the recently announced zero-g fuel feed system based on the surface tension of cesium (M/R, Sept. 7, p. 24-26.)

RL-10 Contract Extended

The space agency has awarded a one-year contract extension for development of the RL-10 rocket engine to Pratt & Whitney Div., United Aircraft Corp.

The $14,790,000 contract provides for continued *Saturn* and *Centaur* flight support, production support and continued development of the advanced RL-10A3-3. Work will be performed at West Palm Beach, Fla.

Shots of the Week

NASA's *IMP-2* monitoring probe was launched from Cape Kennedy on Oct. 3, but fell short of its intended orbital path. Apogee was supposed to have been 161,000 mi., but the space lab reached a maximum of only 59,400 mi. in its elliptical circuit. Reason for the failure was not immediately determined, but the X-258 third stage of the *Delta* vehicle has been blamed for similar failures in the past when it has failed to produce the required kick.

- An AF Strategic Air Command crew successfully launched a *Titan II* missile from Vandenberg AFB, Calif., Oct. 2 on a training mission. The missile also carried an experimental re-entry vehicle (see item p. 10).
- The Soviet Union on Oct. 6 launched the 47th satellite in its *Cosmos* series.
- The Air Force used a *Thor-Able star* booster to launch a secret satellite toward polar orbit from Vandenberg AFB, Calif., on Oct. 6.

Marshall Issues 25 RFQ's

Marshall Space Flight Center has requested quotations from 25 firms for instrumentation for use in an extension to the *Saturn V* ground support equipment test facility. Deadline for quotations is Oct. 23.

The facility will be used to test swing arms, hold-down arms and ground support equipment components before shipment to Cape Kennedy. The initial portion is now nearing completion.

AIAA Nominates Horner

Richard E. Horner, senior vice president of Northrop Corp. has been nominated president of the American Institute of Aeronautics and Astronautics replacing Courtland D. Perkins, whose term expires in January.

Information Exchange Improved

NASA and the Dept. of Defense have agreed to adopt a common system for the exchange of information on research and technology.

The agreement, signed by NASA Associate Administrator Robert C. Seamans and Dr. Harold Brown, Director of Defense Research and Engineering, is designed to improve communication and coordination between the two agencies and reduce duplication of effort.

Both agencies will now use a standard reporting form, covering about 45,000 items of research work, for information exchange. The forms are concerned with "work units," an element or effort with a "task area." Officially, a work unit is a "natural unit into which research and applied research projects are normally divided for purposes of local administration . . ."

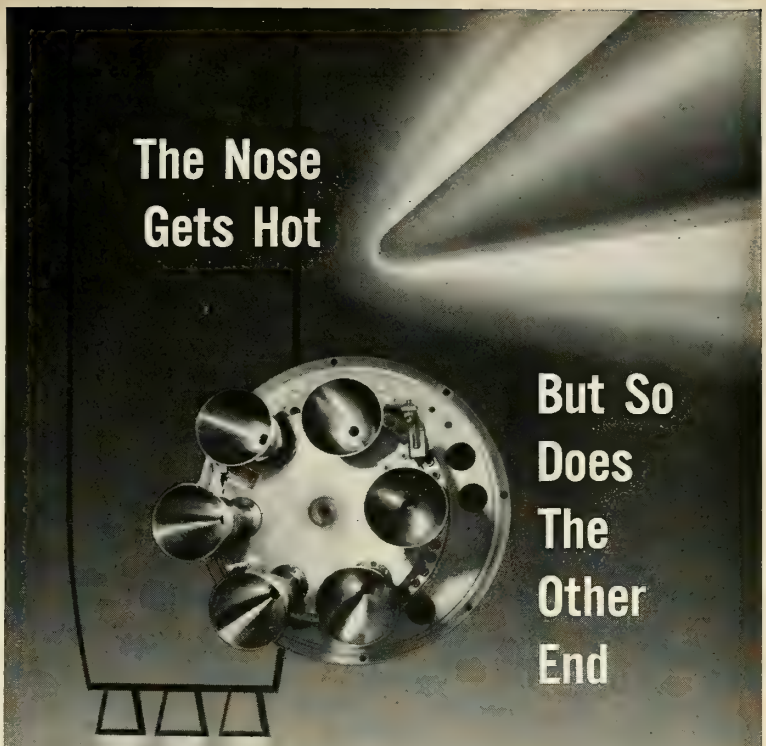
Interim ComSat Head Named

John A. Johnson, vice president-international of the Communications Satellite Corp., has been named chairman of the international Interim Communications Satellite Committee. He will serve one year.

Fifteen nations were represented at the committee's first meeting in Washington Sept. 29-Oct. 2.

Three more nations formally signed the international agreements establishing the global communications system, bringing the total to 16 countries and Vatican City. New signatories are Ireland, Belgium and Sweden.

Next meeting of the Interim Committee will be Nov. 3.



The front-end heat transfer problems of hypersonic flight — nose cone configurations, spacecraft designs, ablative cooling methods — are studied in many laboratories. Aside from extensive programs in these well-publicized areas, however, Cornell Aeronautical Laboratory plays a leading role in solving the equally important but less understood problem at the other end of the missile: the destructive heating of the missile base.

The possible result of radiation, external burning of fuel-rich mixtures, and interaction and reverse flow of exhaust gases, base heating of rocket vehicles at high altitudes has been recognized as one of the major causes of mission failures.

Extensive Cornell Aeronautical Laboratory experience in shock tube technology has been adapted to this problem, with particular emphasis on the NASA/Marshall Space Flight Center Saturn program. CAL's researchers duplicate rocket motor operations at model scale through a pressure altitude ranging from sea level to 350,000 feet. Variations of base heating with Reynolds number have been investigated and base recovery temperatures determined. Resulting data have been highly significant in the design and subsequent successful flight testing of Saturn stages.

This applied hypersonics project is only one of the areas of research in which CAL's technical staff is leading the way.

Others include computer sciences, applied physics, electronics, operations research, aerodynamic research, flight research, applied mechanics, vehicle dynamics, life sciences, and systems research. If your experience qualifies you to join this team, we invite you to mail in the coupon below. It will bring you an interesting briefing on this community of science.

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HONEYWELL CERAMICS ADVANC



"BIG BENDER" is one of the most compact low-frequency sonar transducers ever built. Designed by Honeywell as a research sound source for the U. S. Navy Underwater Sound Laboratory, New London, Conn., this three-ton unit is made up of 90 bender bars, each of which uses 52 elements of Honeywell K-12 precision ceramics that are machined to within two-thousandths of an inch. The ceramic bender bars are able to withstand high internal stresses resulting from the large excursions necessary to produce a four-kilowatt output at 117 cycles per second. The "Big Bender" has an electroacoustic conversion efficiency of greater than 50 per cent and is capable of operating for one year at depths to 1000 feet. Similar Honeywell bender transducers operating at somewhat higher frequencies have shown efficiencies as high as 60 per cent.

ONAR TRANSDUCER TECHNOLOGY

High-efficiency ceramics extend the range and durability of sonar transducers

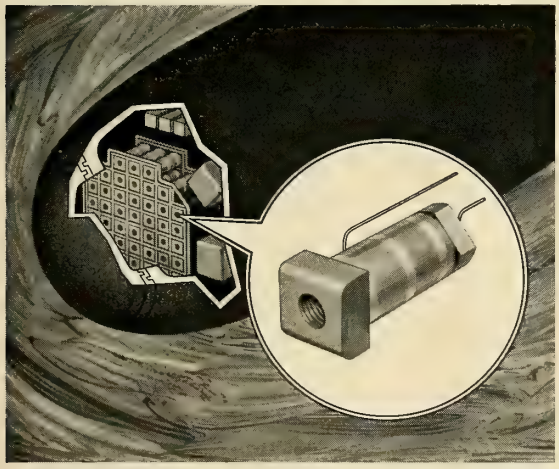
Through significant advances in underwater acoustic technology and high-efficiency ceramics, Honeywell has been able to design sonar transducers that provide lower frequencies, lower operating depths and higher power for some of the nation's most advanced underwater sound programs.

To meet these requirements, Honeywell is producing three types of ceramics that are now available to the industry:

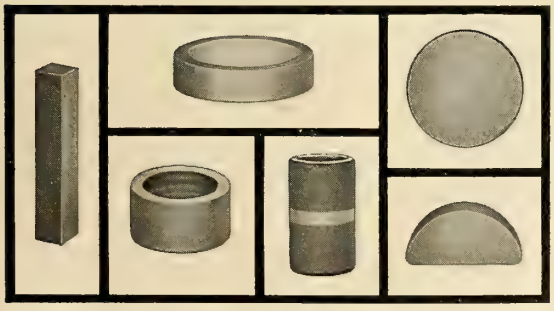
- Lead zirconate/titanate
- Modified lead zirconate/titanate
- Barium-titanate

This range of basic materials, coupled with Honeywell's unique capabilities in custom-building elements of various piezoelectric properties, provides a selection of *quality ceramics* that meets the demands of the most advanced sonar transducer designs.

Although it is common practice to test each ceramic element before it is included in a system, the quality of Honeywell ceramics is so consistently uniform that many customers use the sampling technique of testing. To achieve such quality, Honeywell maintains stringent control procedures throughout its ceramic manufacturing process. All ceramic materials meet IRE standards for electrical properties and are guaranteed to meet minimum standards. When the ceramic materials are processed, automated equipment controls and records the process. The result is uniform ceramics which permit sonar transducers to reliably meet design specifications at high power over long periods.



ADVANCED TRANSDUCERS FOR ASW VEHICLES are being developed and produced by Honeywell. The multi-element array shown is a highly directional transducer designed for use in a sonar projector-receiver system.



CERAMIC TRANSDUCERS of various shapes, sizes and characteristics have been brought to a high degree of development by Honeywell. Having a high rate of exact reproducibility of electrical and mechanical properties, these ceramic elements meet specifications for a variety of acoustic applications.

Honeywell transducers operate in all types of undersea conditions

The ultimate performance of a sonar system depends critically on its transducer, and a transducer is no more effective than its ability to meet system requirements in the prevailing acoustical conditions of a body of water.

At Honeywell, achieving the best combination for a particular application results from close cooperation between the transducer designer and the systems engineer who consider trade-offs such as bandwidth, efficiency, depth capability, and the electrical system parameters governing the performance of transmitters, receivers, and beam-forming and signal-processing networks.

During ten years of participation in the Navy's sonar programs, Honeywell has gained a thorough understanding of underwater acoustics, undersea warfare systems and sonar instrumentation. This has resulted in the design and production of a successful family of sound projectors and hydrophones including:

- Longitudinal vibrators
- Circumferential vibrators
- Flexing-disc transducers
- Flexing-beam projectors ("bender bars")
- Extensional-flexural elements and arrays
- Reference hydrophones

Each of these configurations requires ceramic materials of the highest uniformity and quality to meet the exacting demands of the particular application. As an example of the capabilities of the ceramics in its systems, Honeywell today produces transducers covering a range of frequencies from 45 cycles through several hundred kilocycles per second, acoustic power ratings of several kilowatts and operating-depth capabilities to the bottom of the deepest ocean trenches.

WE INVITE YOUR REQUEST for further information on Honeywell ceramics or sonar transducers. Please specify your interest by writing on your letterhead to Honeywell, M.S. 847, 600 Second Street North, Hopkins, Minnesota 55343.

Honeywell

An exclusive report . . .

NATO Plans SAGE-Type System

NADGE Europe's biggest electronics program; with other NATO infrastructure projects, affords billion-dollar market

by William Beller

PARIS—NATO is about to tie together its European antiaircraft defense into what is expected to be the most modern air-defense system yet devised.

The program will be the biggest electronics project in Europe—budgeted at $308 million. Known as NADGE (NATO Air Defense Ground Environment) it is a SAGE-like system.

Composed of radars, data-handling and communications equipment, NADGE will be used to detect airplanes, receive and process data, and give commands to NATO weapons installations, fighter aircraft and missile batteries.

Distribution of NADGE requests for proposals to industry in NATO countries is imminent. It is expected that a contract will be signed with a consortium by mid-1965.

A historic note was struck when the NATO Council agreed to spend 30.85% of the NADGE program money with U.S. industry. This figure is the proportion of NATO Infrastructure expenses currently paid by the U.S. government. Other NATO countries (except Luxembourg and Iceland) will similarly get a return on their current NATO Infrastructure contributions.

Elements of U.S. industry and government have criticized this formula on the basis that such an electronics project is a "natural" for U.S. industry, which otherwise could have won more than its allotted percentage.

However, many members of the U.S. delegation to NATO and several representatives of U.S. industry here do not share this view.

● **A billion dollars left**—NATO Infrastructure is the commonly funded program of fixed installations necessary for deployment of NATO troops—airfields, missile bases, telecommunications, fuel pipelines, and naval bases. (Infrastructure is a French word originally used in railroad construction to designate the physical facilities necessary for a railroad line such as the road bed, bridges and culverts. It is now internationally accepted to denote fixed installations both of a defense and non-defense nature.)

NADGE is only one of NATO's Infrastructure projects. In fact, the money to be spent for NADGE is a small part of the nearly $3.5 billion that NATO, since 1951, has agreed to spend on its Infrastructure programs. A high-ranking NATO official estimates that nearly one billion dollars, or about one-quarter, of this money is yet to be spent.

He further told MISSILES AND ROCKETS that unlike the early Infrastructure money, used chiefly for airfield construction and other concrete-pouring jobs in which local industry had the advantage, much of the yet-unobligated money will be spent on advanced communications, data processing and other electronic equipment which only highly industrialized countries can produce.

The average annual increment for NATO's common Infrastructure fund over the past eight years has been on the order of $175 million. The present four-year program terminates in 1965, but steps are under way to assure its continued growth.

With Infrastructure installations becoming more sophisticated, the opportunity for U.S. industry to do business with NATO has increased. Yet because a large part of American business seemingly is unacquainted with the operation and mission of NATO Infrastructure, the Dept. of Commerce may soon set up a commercial aide in Paris to help U.S. industry learn more about it.

This suggestion has been made by several industrial and government sources, especially since within the next year or so NATO Infrastructure expects to spend more than $100 million for electronics and communications equipment over and above the NADGE project.

● **NADGE consortia forming**—Early this year, the U.S. delegation in NATO was able to inform U.S. industry on a classified basis of the preliminary plans and specifications of NADGE. As a result, several consortia were formed between U.S. and European companies. One is headed by Litton Industries; others are said to be headed by Hughes and Westinghouse.

There is little doubt that one consortium will handle the entire NADGE project. However, this group will be required, as part of its bid, to allot to industry in each NATO country an amount of business proportional to the relative contribution of that country to the current NATO Infrastructure budget. It is understood that this is the basis on which some consortia are currently organizing.

It is not yet clear which NATO office will eventually implement NADGE. Thought is being given to setting up a new office whose sole mission would be this project. Nevertheless, the contact point for U.S. industry interested in NADGE (as well as in other Infrastructure work) is the U.S. delegation here.

With the exception of NADGE, all Infrastructure projects are carried out by host nations as agents. This means that the contracts are awarded not by NATO or Infrastructure but by the construction or procurement services of these nations. "There are NATO rules to ensure fair international competition, but it must be remembered that the rules and procedures of the host country must be observed as well as those of NATO," Morris Chase, head of the Infrastructure Directorate, told M/R.

"One of the significant contributions to international cooperation has been the introduction of an international competitive bidding procedure to ensure the best and fairest value for each Infrastructure dollar spent," he added.

The Infrastructure program is administered by two senior Committees of the NATO Council: the Infrastructure Committee, which makes policy; and the Payments and Progress Committee, which exercises budgetary control. They are assisted by the NATO International Staff Infrastructure Directorate, which is the largest office in the NATO headquarters in Paris. This Directorate is part of the Production, Logistics and Infrastructure Div.,

COMMON INFRASTRUCTURE PROGRAMS

IN MILLIONS OF DOLLARS		TYPE OF PROJECT
Slice I in 1949	100	(Non-NATO—Western Union) airfields and signals communications.
Slice II in 1951 Slice III in 1952 Slices IVa and IVb in 1952 Slices V, VI, VII in 1953	1,830	Airfields, signal communications, war HQs, POL system, naval facilities and training installations.
Slices VIIb, VIII, IX, X, XI in 1956	850	Airfields, signal communications, war HQs, POL system, naval facilities, early-warning radar installations (forward scatter), ground-to-air missile sites.
Slices XII, XIII, XIV, XV, in 1961	700	Similar types of works as for the preceding slices plus electronic devices for air-defense installations including NADGE.
Total for the 15 slices financed by NATO	3,480*	

* About 25% still unobligated.

headed by Johnson Garrett, Assistant Secretary-General.

● **Spurred by White House**—The White House, as well as the U.S. Dept. of Defense, has been taking an increasing interest in boosting sales of U.S. defense products overseas. In addition to improving the defense of Europe, the Administration is eager to encourage U.S. defense sales abroad to stem this country's gold flow. Last year the outflow amounted to about $2 billion—almost exactly the amount used in the same period to support American military forces abroad. Thus, the U.S. government set a goal of $1 billion in defense materials sales overseas for 1964, and increasing amounts for subsequent years.

To aid in this effort, Roswell Gilpatric, then Deputy Secretary of Defense, sent a letter last year to high U.S. government officials abroad urging them to help U.S. industry in its sales efforts. Many U.S. ambassadors and highly placed generals at first were cool to the idea because, as one of them put it, they did not consider themselves "over here to sell for U.S. companies." But this attitude has softened considerably under continuing DOD and industry pressure. The feeling now is that American firms should be put at least on the same footing as their European competitors.

"By God," said a member of the U.S. delegation to NATO, "there's not a (U.S.) Government man in Europe who doesn't have the word now."

He hastened to point out, though, that U.S. government interest alone will not make business for U.S. companies. "They will have to be competitive and build on the opportunities at hand—such as NADGE," he said. He estimated that about two-thirds of the NADGE money will buy radars, data-handling and communications equipment. The rest will go for installations and checkout.

Further opportunities lie in the follow-on work. A NATO official estimates that an amount of money equal to about one-fifth the total cost of NADGE will be needed each year to pay for its operation and maintenance. Of this, he felt, U.S. industry could get at least five or six percent.

● **Aid from U.S. delegation**—Asked how the U.S. delegation to NATO is helping U.S. industry, John Hooper, Defense Advisor to the delegation, with rank of minister, said, "U.S. industry is getting equal and timely access to NATO information—sufficient to put U.S. industry in a competitive position with industry of other countries." He said that the help his staff is giving U.S. industry is the result of earlier positive steps taken by DOD.

As an example, Rear Adm. William E. Sweeney, Director of Research, Development Projection and Logistics Div. (U.S. Delegation), told of recently forming an adjunct to the Secretary of Defense's Defense Industry Advisory Committee (DIAC) to act as an advisor to the U.S. delegation to NATO. While DIAC is made up of 25 key industrialists in the U.S., the European counterpart called DIAGE (Defense Industry Advisory Group, Europe), has nine members, each a representative in Europe of a major U.S. company.

Chartered by the Secretary of Defense, DIAGE ties in with the Export Subcommittee of DIAC through its chairman, Henry Kuss, Jr. One of DIAGE's current projects, begun only last month, is to analyze the procurement policies of each NATO country and report on them for the benefit of the U.S. industrial community as well as for the U.S. government.

● **Research directors' summit**—One of NATO's big problems is the difficulty in getting countries to agree on jointly producing new weapons or weapons systems made in one of the countries, particularly if they are expensive and can be made equally well elsewhere in NATO. "Suppose we have to choose a V/STOL for NATO," proposed Dr. John L. McLucas, NATO Assistant Secretary General, Scientific Affairs Div. "How do we do it? Each country likes its own."

The solution, McLucas suggested to M/R, is to "divide the pie before it is baked." This will be the work of a newly organized NATO committee, which McLucas chairs, called the Defense Research Directors Committee (DRDC); it will work in close cooperation with NATO's Armament Committee. Representing the U.S. will be Dr. Harold Brown, Pentagon Director of Defense Research & Engineering. His counterparts in the other NATO countries will also be on the committee.

DRDC meetings, the first of which was scheduled to be held here last week, consider the advanced projects needed by NATO, and then how best to divide the work among the NATO nations. By this means, "there will be no problem of considering existing weapons systems, because they will not have been born," said McLucas.

At the same time, the Science Div. will also deal directly with the NATO military, learn their needs for the late 1960's and early 1970's, and feed them to the DRDC for discussion and recommendations.

McLucas also wants to take advantage of the contributions that operations research can make toward NATO force planning for the 1970's. As a first step, he is trying to organize an international operations research conference to be attended by key workers from the NATO countries, who will give papers and discuss the various aspects of force planning.

The work of McLucas complements the Infrastructure program and is outside it with respect to weapons themselves—but not with respect to their fixed installations and integration into a defense system.

The NATO Infrastructure program is often cited as one of the alliance's great accomplishments. Since its inception 14 years ago, several thousand projects—some small and others costing millions of dollars—have been built, from the North Cape of Norway to the easternmost boundary of Turkey. These include over 200 airfields, 5,000 miles of pipelines, over two million cubic meters of fuel storage, 30,000 miles of communications links, dozens of naval bases and hundreds of missile bases.

With the advent of NADGE, and logical follow-on projects, NATO Infrastructure is moving into an area in which U.S. industry can effectively compete with European companies. ■

TMRBM, Based on Minuteman II, Studied as Replacement for MMRBM

by James Trainor

THE DEFENSE DEPARTMENT is moving to fill the gap left by cancellation of the *Mobile Medium Range Ballistic Missile* (*MMRBM*) with a "two-thirds *Minuteman II*." Billed as the *Transportable Medium Range Ballistic Missile* (*TMRBM*), the new system would use the second and third stages of the advanced *Minuteman*, plus that ICBM's guidance system.

Development costs for such a missile, Defense officials say, would be one third to one-fourth the $700-800 million estimated cost of *MMRBM*. In fact, the entire emphasis in the two-thirds *Minuteman* concept is on low-development-risk, off-the-shelf hardware. "Where there is a development risk involved, we have invited alternatives," a Defense official told MISSILES AND ROCKETS, "but we don't want a new bird."

The Air Force has been directed by Defense Research and Engineering officials to study the *TMRBM* to determine whether a practical weapon can be developed with less development risk than in *MMRBM*.

This study was ordered in February or March of this year and is to be submitted to DDR&E by late November or early December. Although this is too late for normal consideration in the Fiscal 1966 Defense Budget, Defense officials point out that funds could be included in the budget in order not to delay the program if the study is approved and development initiated.

● **Limited mission**—The transportable missile would have a sharply limited mission, as DDR&E sees it. It would be used primarily as a system that could be introduced into a crisis situation to favorably influence, or restore, the balance of power. Consequently, the system must be capable of world-wide rapid deployment in C-130, C-141 or CX-HLS-type aircraft.

Unlike *MMRBM*, there are no plans to have this missile roving over the European continent and there has been no serious consideration of the system as a substitute for the *Polaris* in the Multilateral Force (MLF) concept (see related story, p. 10).

A DDR&E official stresses that the fact that *TMRBM* is being pursued should not be interpreted as a decision on DOD's part to proceed or not to proceed. "There is no requirement for *TMRBM*," he points out, "and there are no performance characteristics."

When the study is received, it will be evaluated and a decision will be made on whether to proceed or not. Still an "insurance" program in DOD's eyes, development of *TMRBM* will depend to a degree on "the international environment" at the time.

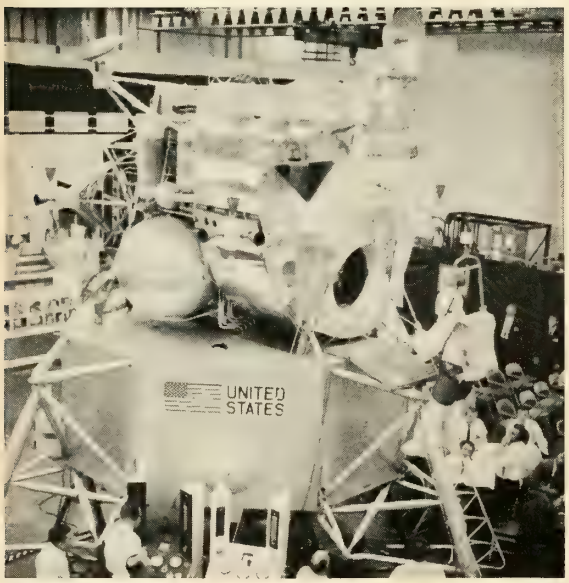
● **Missile description**—The transportable missile will have a range substantially the same as that planned for *MMRBM* (300-1,500 n. mi.) and will be self-contained in one army-type tractor-trailer. Weight of the system will be more than that of the *MMRBM* (11,000 lbs.), however. Reaction time of the *TMRBM* will be greater than for *MMRBM*—primarily because of the requirement to provide the missile with more launch position information than would have been required with the Stellar Inertial Guidance System (STINGS).

Rather than the "cold launch" contemplated in *MMRBM*—ejecting the missile from a tube before igniting—it appears that the *TMRBM* will be launched directly from the transporter.

Command and control requirements for the *TMRBM*, however, are expected to be as severe as they were for the *MMRBM*. Therefore, "unless the study indicates otherwise," a DDR&E official says, "we will use the command and control system developed for *MMRBM*."

● **Short development time**—The *TMRBM* study—conducted by Aerospace Corp. and TRW/Space Technology Laboratories—has been completed and submitted to the Air Force Ballistic Systems Div.

If approved for development, the *TMRBM* could be developed in "substantially shorter time than the *MMRBM*." *TMRBM* grew out of a Boeing Co. proposal to DOD in March, 1962. ■



LEM Metal Mockup Unveiled

FIRST full-scale metal mockup of the NASA/Grumman Lunar Excursion Module is shown at unveiling at Grumman's Bethpage, N.Y., facility Oct. 8. The mockup, mostly aluminum, was critiqued by space agency and Grumman officials to finalize the design.

Anderson demands NERVA flight funds . . .

Phoebus-Powered Second-Generation Engine To Have 250,000 lbs. Thrust

by Hal Taylor

THE JOINT NASA/AEC Nuclear Propulsion Office has revealed that the second-generation nuclear rocket engine will have a thrust of 250,000 lbs.

The engines will be clustered in twos or fours to provide the minimum 1 million lbs. of thrust required to launch manned spacecraft from Earth orbit on planetary flights to Mars. One or two would be used to brake into the Martian atmosphere.

The engine will be powered by the Phoebus reactor, which has a design power level of 5,000 megawatts.

Details of the Phoebus and engine programs were described by Harold B. Finger, director of the joint office, at the second NATO Advisory Group for Aeronautical Research and Development (AGARD) series of lectures on nuclear propulsion in Brussels.

He said the engine will be the highest-thrust powerplant that can be built using essentially the design concepts, control schemes, and material capabilities proved in the KIWI reactor and *NERVA* engine.

● **Flight funds demanded**—In another nuclear propulsion development, Senate Space Committee Chairman Clinton Anderson (D-N.M.) called on NASA to make available "an effective level of funds" for flight tests of the *NERVA* first-generation nuclear engine.

He said the success of the recent test of *NERVA's* NRXA reactor at the Nuclear Rocket Development Station in Nevada (M/R, Oct. 5, p. 12) supports the argument that flight-program funding is needed.

"The nuclear-powered rocket, while recognized as an efficient system for long voyages into outer space, including interplanetary travel, may have a more immediate role to play as a logistic vehicle for a manned station on the Moon, if this is to be the nation's next program in space," he declared.

The reason given for dropping flight funding from the agency's Fiscal Year 1965 budget was that the rockets would not be needed until the late 1970's or early 1980's.

Anderson called on NASA to request funds for the project in the budget now being prepared for the next fiscal year. Informed sources report, however, that it is unlikely such a request will be made in FY '66. They are optimistic that the funds may be in the FY '67 budget

● **Schedule**—The NRX (*NERVA* Reactor Experiment) reactor firings will continue next year in Nevada; three more tests are scheduled.

At the same time, NASA and the AEC will initiate the first firings of the Phoebus reactor. Three or four reactors —based on KIWI and NRX technology and with about the same power level— will be tested in 1965 and 1966.

In 1967, the first tests on the heavier Phoebus reactor will begin. This will be five times more powerful than the NRX reactor, which has a power level of 1,000 megawatts and a thrust of only 50,000 lbs.

At this point, there is no definite date for starting development of the second-generation engine. The best guess is later this decade—with 1967 the earliest date but 1968-69 more probable.

Development of the technology for major engine non-reactor subsystems—such as feed systems and nozzles—has begun, Finger told the meeting.

● **Obstacles**—One significant problem facing the engine program is nozzle development testing. Simulation of such testing with a reactor is difficult and has not yet been accomplished. A new Hydrogen Heat Transfer Facility will be constructed by mid-1965, permitting the first testing of realistic scale nozzles in hot hydrogen for long periods.

The feed system presents a problem because of the requirements for increased hydrogen flow for the Phoebus Reactor testing. Finger said that ways of modifying the pump used in the *NERVA* testing are being studied. Consideration also is being given to meeting feed-system requirements for higher-power reactors by modifying pumps under development for high-thrust hydrogen-oxygen engines such as the J-2 and M-1. ■

Apollo Modules Lightened

Shortening the propellant tanks of the *Apollo* spacecraft's Service Module has reduced its weight by some 3,000 lbs.

In another design change, the adoption of a new lightweight heat-shielding device for the Command Module has trimmed its weight by 350 lbs.

The shortening of the propellant tanks by 12 in. and other changes were revealed at a press conference held by Manned Spacecraft Center officials at North American Aviation's Space & Information Systems Div., Downey, Calif.

The group, including 16 astronauts and headed by Robert O. Piland, deputy manager of NASA's *Apollo* Spacecraft Project Office at Houston, earlier had conducted a complete mockup review of the lunar-mission version of both the Command and Service Modules and qualified the modified design configuration as final.

Shortening of the tanks is the only modification of any consequence in the Service Module and will have no effect on overall configuration of the system. The reduction became possible when it was determined that less reserve propellant would be needed than had been originally estimated.

Modifications to instrumentation of the Command Module also have been approved. The main instrument console will comprise three large self-contained units, all pre-assembled and prewired before installation in the craft. The guidance and navigation and stabilization and control systems are now integrated into a single system. Also, the caution-warning system's display unit is being repackaged and the system's capacity increased.

In-Flight Maintenance Stressed In Manned Missions Beyond Apollo

by Willard E. Wilks

LOS ANGELES—Discussions at the Society of Automotive Engineers' national meeting pinpointed the need for in-flight maintenance and checkout on extended manned missions as having a heavy impact on future spacecraft design.

Examination of problems associated with manned missions beyond Project *Apollo* dominated the space portion of the Oct. 5-9 aeronautic and space engineering and manufacturing meeting here. The in-flight maintenance problem was particularly emphasized, with General Dynamics/Astronautics reporting it has adopted a "no tools" design philosophy that seeks to eliminate the need for astronauts to use hand tools in spacecraft maintenance and repair. The GD/A approach was reported by John R. Burnett.

• **No hand tools**—GD/A applied the philosophy that servicing and component replacement should be possible without use of hand tools in conducting life-support system development and test work for NASA. When hand tools were required, it was treated as an exception to the specification and specifically reviewed, Burnett said.

To broaden application of this approach, the GD/A study recommended development of better methods to achieve component interchangeability, to reduce and simplify spares, and more study of materials to increase design effectiveness with respect to its management by the crew.

• **MTBF weakness**—In a study by the Aeronautical Div., Honeywell Inc., R. W. Tillotson reported that despite the best efforts of the design and reliability engineer, the mean-time-between-failure (MTBF) of present systems is only 1/10 to 1/20 of the MTBF required to assure a reasonable probability of mission success on long manned flights.

Use of the crew to provide redundancy, manual backup and in-flight replacement of subassemblies appears the practical route to solving this problem.

In-flight maintainability must become a primary design parameter on a total system basis once the decision is made to use it to achieve reliability goals, Tillotson said. This will affect future manned spacecraft design by requiring that system elements be packaged so that each subassembly contains those components associated with a single system function (or several serially related system functions), and that adequate physical and visual in-flight access be provided.

• **Launch pad changes**—In addition to affecting spacecraft design, a Martin Co. researcher suggested, the necessity for conducting on-board checkout, countdown and emergency repair during extended missions also could drastically affect launch pad design.

William O. Campbell of Martin Co., discussing the requirements for putting "GSE (ground support equipment) in the vehicle," said launch-pad simplification appeared to be one problem associated with this requirement that was capable of direct solution.

If there is GSE in a vehicle for space use, the same GSE will be used in the vehicle during its factory-through-launch pad life span, Campbell pointed out. "Eventually the seat of checkout responsibility could reside in the vehicle," he said. This will mean extensive use of telemetry to transmit data from the vehicle to ground equipment, eliminating the downgoing umbilicals, and use of an on-board stimulus box to give checkout commands to various flight hardware systems, eliminating the upgoing umbilicals.

Such considerations have resulted in a Martin launch-pad concept in which base fueling eliminated the need for a servicing tower. ■



Infrared Photo of LPC Firing

THIS PHOTO of Lockheed Propulsion Co.'s successful 156-in. solid motor firing Sept. 30 was taken by an infrared camera. Entire nozzle end of motor is obliterated by heat effect of 5,500°F exhaust gases, and plume appears much broader at nozzle than it did to the eye or on standard film. Radiant effect is also noticeable on hillside to left of motor. Fully successful test was conducted by Lockheed for Space Systems Div., Air Force Systems Command. The motor produced about 1.2 million lbs. of thrust during a burn time of two minutes, 25 seconds. The motor was fired for the first time last May 28, but the Sept. 30 test produced 30% more thrust than the first shot because the case contained 30% more propellant—a total of about 650,000 lbs. The Air Force is now expected to begin a more concentrated push for development of some applications it has under study in the 156-in. program. A significant result of the latest firing was proving a new nozzle concept that will be used on the two-segment, three-million-lb.-thrust 156-in.-dia. motor to be fired by the Air Force at Thiokol Chemical Corp.'s Brunswick, Ga., facility in December. An Air Force spokesman said they can use an essentially plastic nozzle.

Technical Countdown

FLUID DYNAMICS

Fluid Control System Flight-Tested

A pure fluid control system has been employed to control the flight of a test instrumentation missile at the Redstone Arsenal missile test range. No moving parts or supporting electronics were required in the system. Developed by Honeywell, Inc., the device uses either a gas or liquid that is directed through various channels to perform control functions. It reportedly is capable of measuring spin rate and converting the rate to a memory of vehicle body position. Fluid amplifier cascades develop the measured signals to power levels sufficient to control missile external reaction jets. The unit tested survived missile impact and operated again after removal from the vehicle remains (M/R, Oct. 5, p. 17).

ASTRONAUTICS

Gemini Ballute To Be Drop-Tested

A personal ballute for *Gemini* astronauts will be drop-tested starting this month on anthropomorphic dummies ejected from a two-seat F-106 at an altitude of 40,000 ft. and a speed of Mach 1.75. Tests at lower altitudes and speeds have been successful. The inflated ballute is supposed to keep an astronaut from gyrating during the long free fall to parachute opening altitude after ejection at altitude. Centrifugal force produced by autorotation of the human body during such a fall can be incapacitating or even lethal. NASA Manned Spacecraft Center has decided to limit ejection-seat use to altitudes under 46,000 ft. during the *Titan* launch phase.

Astronaut Flyweight Stabilizer Developed

The Air Force Aerospace Medical Research Laboratories has developed a device that could be used to maintain stability for astronauts maneuvering in space. The device, a flyweight weighing about 10-20 lbs., is tied to one end of a cord, the other to the astronaut. If the spaceman starts to tumble or spin, the flyweight is released. A friction device is used to uncoil the cord through to keep it from wrapping around the astronaut's body. A small scale model has been tested with good results in the zero-g parabolic flight aircraft at Wright-Patterson AFB.

ADVANCED MATERIALS

Lewis To Build Nuclear Test Chamber

Nuclear auxiliary power generating systems will be tested for space use in a new environmental chamber at NASA's Lewis Research Center, Plum Brook Station, Sandusky, Ohio. Measuring 100 ft. in diameter and 120 ft. high, the chamber will use Consolidated Vacuum Corp.'s new 48-in. BlueLine vacuum pumps to simulate an altitude exceeding 100 mi. Thirty-two pumps, each rated at a speed of 200,000 cu. ft. of air per minute, will be used. The chamber is the first designed to test both space nuclear power and nuclear propulsion systems.

Consarc Furnace Improves Alloy Ingots

High quality vacuum-melted alloys for forging stock are now being produced by Union Carbide's Stellite Division in Kokomo, Ind. Using the new Consarc vacuum-arc furnace, Stellite claims a great improvement in ingot surface quality, including elimination of carbide segregation and "freckling." (The latter is the unwanted formation of intermetallic compounds.) Ingot structure improvements have also been shown, says Stellite. The new furnace has the capability to produce 30-in., 15-ton ingots. Believed to be the most sophisticated consumable-electrode system in operation anywhere, it approaches complete operational automaticity. Hydraulically operated, the two-station unit requires only a 20-min. cycle per unit from electrode-arc to final ingot.

SPACE MEDICINE

Spacecraft Cabin Atmospheres Still a Problem

Experiments with helium-oxygen spacecraft cabin atmospheres by AiResearch indicate the combination would ease the problem of holding cabin temperatures down, since optimum comfort levels seem to be about 6°C higher than in a denser nitrogen-oxygen cabin atmosphere. The main advantage sought in a helium-oxygen cabin atmosphere is avoidance of the bends when astronauts must transfer from 7.5 psi two-gas cabin atmospheres to 3.5 psi pure-oxygen spacesuit asmospheres. Navy submarine experiments have proven that helium does offer this protection, though it has not yet been explained. Other inert gases have been suggested as possible oxygen diluents for cabin atmospheres. None appears very attractive. Neon remains a possibility. Possible engineering disadvantages of helium-oxygen that must be investigated include increased leakage caused by the lower density of the atmosphere. However, first-look data indicated to AiResearch engineers that it should be as easy to handle as nitrogen-ogygen.

GD Life-Support Systems Readied For Tests

General Dynamics' fully integrated life-support system capable of supporting a four-man crew in space for a year has undergone final inspection at the Astronautics Div. plant at San Diego. After several short manned tests, the two-level chamber with prototype space-station equipment will be shipped to Langley Research Center next spring. NASA plans to keep the subsystems updated as new technology develops.

Space Tools To Be Tried Under Zero-G

A number of *Gemini*-type tools and other equipment will be tested in a new facility developed by the Air Force Systems Command's Research and Technology Div. to test space maintenance techniques. The Martin-built facility includes an air-bearing six-degree-of-freedom simulator and work panel, jet-propelled back packs, a remote maneuvering simulator, and a *Gemini* capsule mockup. About 20% of the equipment testing will be done in this facility, with validation flights on weightless maneuvers in a C-131 aircraft.

Closed Cycle Waste System at Marquardt

A closed system for management and regeneration of wastes is being developed by Marquardt Corp. for NASA's Manned Spacecraft Center at Houston. The distillation/vapor condensation process will be designed to handle waste output of four astronauts during a 14-day mission, but have potential for operating one year. Water for drinking and washing will be reclaimed.

Bell keeps ahead

Machines

$14,000,000 for new precision equipment, numerically controlled machines, data processing and controlled environmental and other plant facilities in 24 months.

Manpower

represented by the talent to design and build the Agena Rocket Engine, Reaction Controls for the Mercury Program, the Bell Rocket Belt, Lunar Landing Research Vehicle, X-22A VTOL Aircraft, HIPERNAS (High Performance Navigation System), Lunar Excursion Module Ascent Engine and SKMR-1 Hydroskimmer.

Management

including all the latest management tools and techniques such as PERT and LINE OF BALANCE programming, Value Analysis, Performance Improvement Programming and other management controls.

...and now a reorganization

to further strengthen the management function to utilize to the fullest these resources of machines, manpower and management tools...to be fully responsive to customer needs by building the best and most reliable products at the lowest cost in the shortest time.

BELL AEROSYSTEMS COMPANY
DIVISION OF BELL AEROSPACE CORPORATION - A textron COMPANY

NASA Pushes Blood Circulation Work

Texas Medical Center gets contract for bed-rest studies of effects of weightlessness; wide range of control techniques being investigated

by Heather M. David

NASA IS STEPPING UP its efforts to find an effective method of preventing cardiovascular deconditioning arising from weightlessness.

Latest move is the award of a $290,000 contract to the Texas Medical Center, Houston, for bed-rest studies which would simulate the weightlessness state and its effect on blood circulation. Researchers are spurred by a desire to get something effective before *Gemini Titan-4 (GT-4)*, a three-day orbital flight scheduled for mid-1965.

Choice of a method will have considerable effect on systems. Means being considered range from one which would have considerable weight, space and power penalty, to one possibility which would have none. Dr. Sherman Vinograd of NASA's headquarters Aerospace Medicine Office says the space agency sees these possibilities:

—*Centrifuge*—Short-radius centrifuge tests look very promising for preventing the orthostatic hypotension which causes pooling of blood in the extremities when the subject is returned to an upright position. Many scientists feel that this will be the only possible method of preventing the degradation of the normal circulatory controls on a prolonged spaceflight. Douglas Aircraft Co., for one, is doing an ambitious series of studies on sizes, diameters, etc., to evaluate the use of the centrifuge in a minimal space cabin.

—*Bicycle ergometer*—NASA is looking at the possibility of installing this type of equipment in a space capsule. Exercise would be calibrated, and the unit would provide a diagnostic as well as conditioning tool.

—*Negative pressure unit*—Use of a negative pressure vest would produce a physiological reaction which would counteract the effect of weightlessness. However, interest at this point is purely physiological, since it would require the engineering of a vacuum unit into a hard-shell spacesuit.

—*Pressure cuffs*—A promising method which interests both the Air Force and NASA. The latter is primarily concerned with cuffs on the legs, since these will account for the largest amount of blood. The cuffs would be automatically inflated periodically, providing the same kind of pressure in the veins as does gravity. Cuffs will be incorporated into the early *Gemini* flights for evaluation and also as a means to assess the astronauts' condition.

—*Exercise*—Isometric exercises, although extremely beneficial to other needs of the body, such as those of the muscles and bones, do not seem to aid the cardiovascular system at all. This conclusion was reached after quite a bit of research by the Air Force at Lackland Hospital, San Antonio, through the AF Aerospace Medical Division. Isotonic exercises are now being investigated by NASA.

—*Valsalva maneuvers*—In this approach, the subject exhales forcibly with his mouth closed. Result is an increased chest pressure impeding the flow of blood to the heart, triggering a reflex which speeds up the heart and constricts the blood vessels in the body, maintaining blood pressure. A calibrated valsalva test instrument has already been developed; the astronaut exhales into it to produce a measured amount of pressure.

—*Drugs*—While there are drugs which will produce the effect upon the cardiovascular system, NASA is doing its best to avoid having to use drugs for any purpose.

● **Bed-rest tests**—The latest bed-rest test, which will be funded by NASA's Manned Spacecraft Center at the Texas Medical Center, will use a total of 66 subjects, divided into groups of six. They will remain in bed for periods of three, seven and 14 days.

Bed-rest has come to be the most popular simulation of weightlessness, superseding water immersion because of considerations such as the pressure on the chest, and the gradient problem. The similarity to weightlessness created by bed-rest does not result from lack of activity, but rather from the horizontal position: the cardiovascular system does not have to work to get blood back to the heart as it does in an upright position.

During the several studies being conducted by NASA, researchers will seek to determine exactly what the mechanism is, what the exact effects are, how to anticipate or predict the effects and assess their severity, as well as how to prevent them. Subjects will get complete medical examinations periodically, including tilt-table tests which are specific for the condition.

● **Scientific controversy**—Opinions as to the cause of the orthostatic hypotension which affected the last two *Mercury* astronauts—Walter Schirra and Gordon Cooper—range considerably. The condition was observable as they emerged from their space capsules—in the pooling of blood in the legs, low blood pressure and dizziness—and lasted for a number of hours after their flights.

Some doctors attribute the effects to fatigue, dehydration, emotional exhaustion resulting from the flights, or combinations of these factors. A larger number feel that weightlessness itself probably was to blame.

The situation is complicated by the fact that with various individuals, any one of these factors probably would be enough to create such effect. Another confusing fact is that, while both astronauts were obviously dehydrated from difficulties with their environmental control systems, an abnormal loss of water is also a possible product of the mechanism which might have caused the orthostatic hypotension—if weightlessness was the culprit.

While the Soviets have hinted at difficulties in their longer spaceflights, according to Vinograd, nothing has been documented in Soviet literature proving this. In addition, there have been hints that they only found the difficulty through special techniques, which have not been explained to U.S. scientists' satisfaction.

Air Force has also conducted ground-based studies on the subject, for NASA and for its own *Manned Orbiting Laboratory* (M/R, March 2, p. 21). ■

Air Force Takes Over Big Rally II Communications System

Project 486L subsystem links sites in Italy, Turkey, Greece and U.S. with 24 voice channels; designed by ITT Federal Electric Corp., system was operational within five months

by Charles D. LaFond



BIG RALLY II, an interim communications subsystem within the Air Force's Project 486L Mediterranean Communications system, has been turned over to the Air Force Communication Service for operational use. Designed and put in partial operation in less than five months by ITT's Federal Electric Corp., Paramus, N.J., the now completed phase-1 system links military centers in Italy, Greece and Turkey to the U.S. through the long-haul telecommunications circuits of the Defense Communications System.

Twenty-four voice channels are provided by the new complex through eight tropospheric-scatter paths and 15 microwave links. Air transportable communications facilities were used throughout the installation to implement early operational use.

Until turnover to the Air Force, the BR-II network has been operated by both Air Force and Federal Electric personnel.

In time, more permanent facilities will be installed under a second portion of the 486L program also being performed by Federal Electric.

● **Contractors**—Project 486L is a segment of the Air Force's global AIRCOM System. ITT Communication Systems, Inc., is prime contractor for AIRCOM system design. Overall responsibility for the system rests with the Electronic Sytems Div. of the Air Force Systems Command.

Principal subcontractors for implementation of each portion of 486L are Federal Electric Corp. (Big Rally II and Europe-Mediterranian Tropospheric Scatter System) and Page Communications Engineers, Inc., a subsidiary of Northrop Corp. (Turkey Troposcatter system).

● **486L system objectives**—Project 486L is intended to provide the Air Force with highly reliable, modern telecommunications in the Mediterranean area. The design requirements demanded system compatibility with the existing and planned Defense Communications System's global telecommunications links.

Three major subsystems comprise the 486L system—Big Rally II, the Europe-Mediterranean Tropospheric-scatter system and the Turkey Troposcatter system (see map, facing page).

In all, 100 sites will be employed in Spain, Italy, Greece, Turkey and North Africa, plus two sites whose locations are classified. Over 8,500 miles of circuits are called for. The longest through-circuit will extend some 2,900 miles.

The main system trunk will provide up to 72 channels, with a capability for expansion to 120 channels.

The 486L system interfaces with the Army communications system in Northern Italy and the Spain-United Kingdom troposcatter system on the west.

● **The interim subsystem**—The largest segment of 486L is the Eur-Med Tropo net. Extending from Spain through the Balearic Islands to Sardinia, into Italy to Greece and Turkey and through Sicily to Tripoli, the EMT system calls for 13 troposcatter and 12 microwave links.

Federal Electric began this effort in June, 1961, following earlier design work by ITT Communications.

However, the August, 1961, Berlin crisis pointed up the urgent need for more rapid expansion of communications facilities in the Mediterranean area.

Big Rally II was thus conceived as an interim system until Eur-Med could be completed. Federal Electric was awarded the BR-II contract in December, 1961, and the mainline trunk connecting Italy and Greece were on the air by April 25, 1962. Tributary links were completed in January, 1964.

Overbuild requirements to convert and upgrade BR-II sites in Greece and Turkey for Eur-Med needs extended the effort to March, 1964.

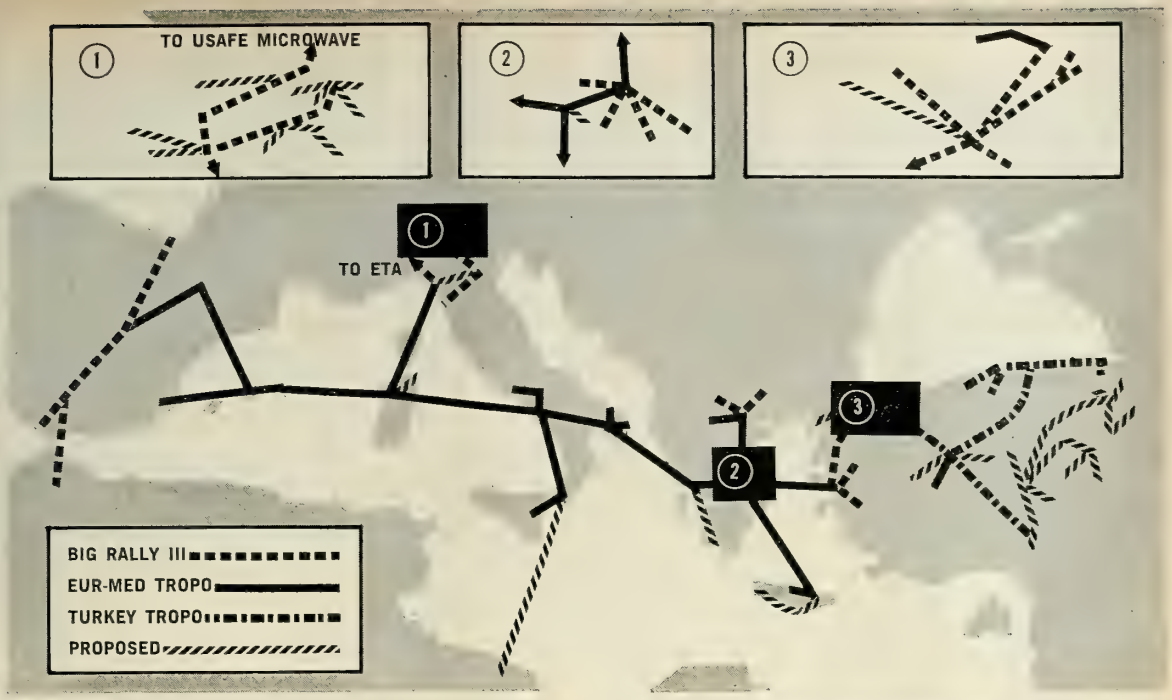
● **BR-II phase-out**—As the Eur-Med Tropo system is phased in, Big Rally II transportable facilities will be removed. Most of the BR II sites have been overbuilt as a part of the Air Force's Turkey Master Plan.

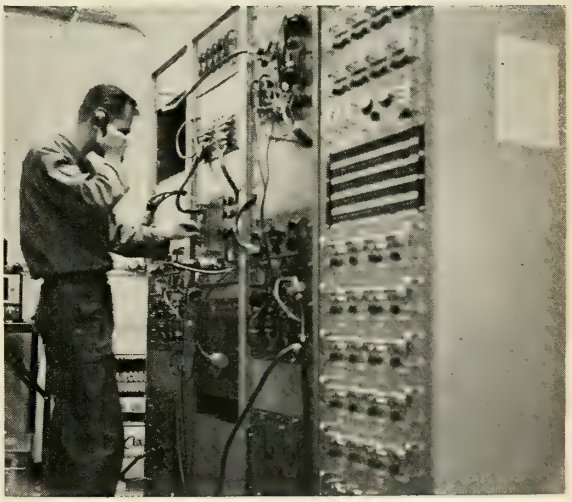
Several more links will be needed in addition to the present three MEDCOM subsystems. These have been included in Project 486L as part of Big Rally II, phase 2, in Fiscal Years '64 and '65.

Altogether, additions will include 12 links in Italy, 3 in Greece, and 17 in Turkey.

● **Operating frequencies**—The operating frequencies for the Big Rally II basic troposcatter trunk are 400 mc and 800 mc (Turkey only). Eventually the Eur-Med system will operate its basic trunk system in the 2,550-2,690-mc range in all locations except Turkey. LOS-microwave links will operate at either 400, 800, or 8,000 mc.

Air transportable tropo systems in use include 1-kw and 10-kw MRC-85's, 1-kw MRC-80's and 30-ft.-diameter paraboloidal-reflector antennas. AN/FRC-39 tropo systems will eventually replace the transportable systems. ■

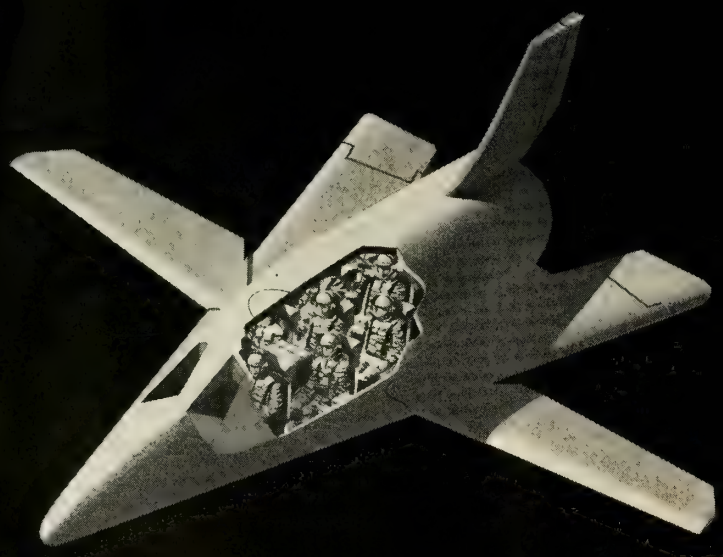




OPPOSITE PAGE: Microwave antennas are beamed at Mt. Parmis, Greece, 19 miles away. AN/TRC-35 "flyswatter" antenna is used for local communications. ABOVE: Air Force MEDCOM communications complex will be comprised of three major subsystems—Big Rally II (an interim system), Eur-Med Tropo, and Turkey Tropo. Map of existing and planned circuits shows trunks running through five countries. RIGHT: All 486L sites ultimately will be manned by Air Force personnel, such as at this Athens Air Base site. BELOW: Typical of 486L stations is one atop mountain near Izmir, Turkey. Initially, transportable MRC-85 tropo units were installed. These have now been replaced with permanently-installed FRC-39 equipment.



What Boeing is doing



bout MANNED SPACE FLIGHT:



Life Support System

Five men recently completed a 30-day NASA space mission—without leaving the ground. A Boeing space chamber (above) simulated long-term space flight conditions. The mission tested water reclaiming and waste disposal systems as well as a method of supplying oxygen with sodium superoxide chemicals. Tests like these help in designing future spacecraft (such as the 12-man variable-wing vehicle concept at left).

Meteoroid Studies

During space travel, vehicles may encounter meteoroids large enough to create a hazard. To measure the danger and to devise a spacecraft protective system for astronauts, Boeing is conducting research for NASA. Using a Boeing-developed gas "gun," researchers shoot pellets at approximately meteoroid speeds (21,000 mph) to test various types and combinations of protective plating for spacecraft.





Vehicle Design

To assist the Air Force and NASA in development of criteria for manned orbital laboratories, Boeing has conducted studies of vehicles utilizing from 2- to 12-man crews. Studies include booster-vehicle integration, life support, micrometeoroid protection and logistics involving crew rotation and resupply.

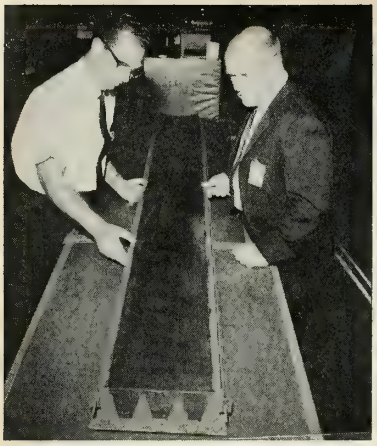
Rendezvous in Space

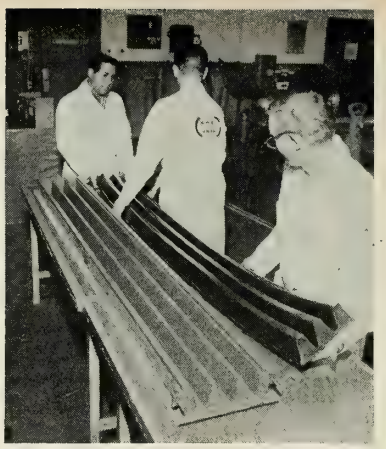
In simulated flights, Boeing is investigating techniques for bringing two orbiting vehicles together in docking missions. The "pilot" sights his target vehicle on a projected TV presentation, and using controls operating through a computer, maneuvers his vehicle through a complete docking run.

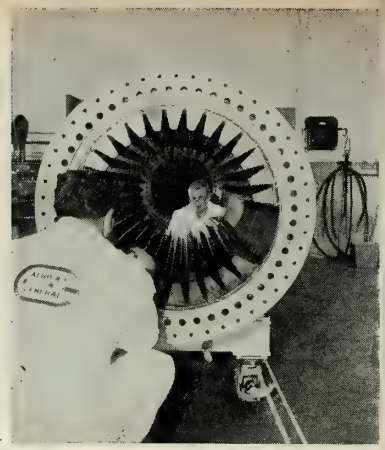


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260-in. Igniter Fabrication Detailed

AN IGNITER MOTOR rated at a maximum thrust of 270,000 lbs. will soon be tested at Aerojet-General's Dade facility in Florida for its role in touching off the huge 260-in.-dia. solid rocket.

Designed and developed by engineers at the firm's Solid Rocket Plant in Sacramento, Calif., the igniter motor holds 1,160 lbs. of a standard polyurethane propellant in a 30-point star grain configuration.

The unit will generate a sheet of high-temperature flame down the 80-ft. length of the 260-in. grain. Tests indicate an ignition time of two seconds.

● **Fabrication**—In fabricating the igniter motor, Aerojet uses a simple, inexpensive mold shown at far left above into which propellant is cast. A liner is applied to the back surface and the entire strip is cured.

The grain slabs are remarkably free from voids and other imperfections in spite of the ambient pressure casting method. Ten of these pre-cast slabs are installed in the igniter motor case forming a 0.5-in.-thick web with a burning surface of 21,000 sq. in.

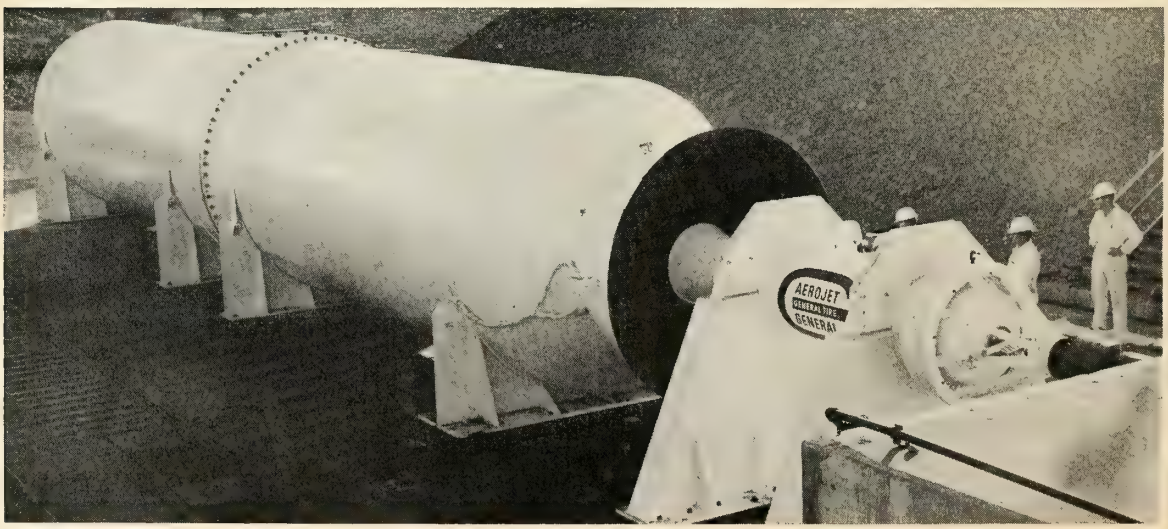
An almost completely assembled grain is visible in the far right illustration above. The igniter is shown below resting in its cradle, with its nozzle directed into a 60-ft.-long, 10-ft.-wide chamber that simulates the core area of the 260-in. solid motor.

The free-volume chamber was instrumented at 14 stations and test data shows a steady state maximum pressure of 90 psia during the ignition transient.

● **How it will work**—This free-volume chamber has been installed in the vertical cast, cure and test pit at the Dade facility. Igniter motors will be tested in this position to check out the concept under actual ignition conditions.

In the actual 260-in. firing, the igniter motor and its 17,000-lb. sled will move up a 68-ft. track after ignition. Cables attached to a 2-million-lb. concrete mass will cause the igniter and its sled to describe an arc and impact some 550 ft. from the large motor. Two such tests will be run before the end of this year.

The first full-scale firing in the Air Force's large motor demonstration program at Aerojet is set for 1965. ■



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Reliability Engineer **BSEE, ME, Physics, Math**	Failure mode and effect analyses, determination of criticality numbers, math models for electrical and mechanical GSE. Also circuit design, logic design.
Reliability Documentation Engineer **BS Engineering**	Standardization and documentation of all components used in GSE. Includes screening of parts for unreliability or obsolescence, compilation of qualified parts list, recommendation of testing programs, and coordination of unsatisfactory condition reports.
Electronic Systems Design Engineer **BSEE, ME**	Conceptual, functional and preliminary design of electrical subsystems and hardware of ground support equipment for launch vehicles. Should include computer applications, digital circuitry or control systems design.
Electrical Circuit Design Engineer **BSEE**	Development, design, analysis and checkout of circuits for servomechanisms in propellant tanking control systems; circuit design such as attenuators, filters and servo controls.
Electrical Circuitry & Packaging Engineer **BSEE, ME, Physics**	Detail design of circuits and hardware for GSE, including black box circuitry and advanced electronic packaging, digital circuitry, logic circuitry, computer applications or electronic hardware for ground based equipment.
Program Control Engineer **College Degree**	Analysis of work flow and schedules using PERT, CPM, line of balance, milestone schedule, use of digital computers for reports to management.

COCOA BEACH, FLORIDA

Experience required in the following areas:

Reliability Engineer **BSEE, ME, Physics, Math**	Analysis of failure mode and effects, redundancy, derating and stress, applicable to instrumentation and mechanical or electrical GSE, including missile handling equipment in assembly buildings, launch control centers and arming towers.
Display and Control Engineer **BSEE**	Analysis of electrical support systems such as TV, communications, water control, power distribution and gas systems. Design and development of changes necessary to provide control, remote control and instrumentation display of such systems up to three miles away.
Systems Checkout Engineer **BS Engineering, Physics**	Preparation of checkout methods, knowledge of planning, supervision and evaluation of checkout of launch vehicle gyro, stabilization and control systems.
Control Systems Engineer **BS Engineering**	Preparation of missile operations plans, identification of requirements, defining specifications and selecting electrical control equipment required for the assembly buildings.

HOUSTON, TEXAS

Experience required in the following areas:

Reliability Engineer **BS Engineering**	Design review, and failure mode and effects analyses of solid propulsion systems and of missile handling and servicing equipment.
Flight & Orbital Mechanics Engineer **BSAE, Physics**	Performance parameters, including earth and planetary, launch and descent, transfer orbits, etc., to be used in the analysis and evaluation of spacecraft design.
Systems Engineer **BS Engineering**	Analyses and evaluation of spacecraft design and ground support electronic systems, propulsion and ordnance systems, and power generation and distribution systems.

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MSC Seen Favoring Concentric Orbit Gemini-Agena Rendezvous

by Jinx Mercer

HOUSTON—Intercepting the *Agena* from an orbit concentric with the target gives *Gemini,* in its first rendezvous attempt, "high probability for mission success."

The plan is "flexible" from the pilot's point of view, Maj. Edwin E. Aldrin, Jr., astronaut and early proponents of the "co-eccentric" method, told MISSILES AND ROCKETS.

"The plan is least susceptible to launch dispersions and non-nominal situations," says Howard W. Tindall, Jr., assistant chief of Mission Planning and Analysis Division at the Manner Spacecraft Center here.

The fourth *Gemini* team (*GT-6*), according to MSC's schedule, will attempt the first rendezvous with the *Agena.*

A simplified rendezvous exercise using a "pod" may be included on the *GT-5* mission, an MSC spokesman said, to flight-check the radar and to practice piloting techniques during the terminal phase of the rendezvous maneuver.

The pod will be ejected from the spacecraft into an orbit that is slightly out of plane. The spacecraft will most likely thrust into a higher orbit to be moved "out of phase" with the pod.

● **Two approaches**—Rendezvous mission planners are making detailed analyses of the concentric plan, Tindall said, "mostly juggling numbers in orbital parameters, altitudes, catch-up rates, and inclination angles" to increase the number of launch windows and to make operations simpler, both in the spacecraft and on the ground.

The tangential method, around which most of the onboard rendezvous systems have been designed, is also going through detailed analyses, he said. "It will most probably be used for later rendezvous missions."

In both plans, the first full orbit after spacecraft insertion remains undisturbed to allow ground controllers and tracking stations time to establish the orbital parameters of the spacecraft, and to give *Gemini* pilots time to check out onboard equipment.

The first required maneuver will be an "out-of-plane" correction (by ground recommendation) at the first nodal crossing of the spacecraft's second orbit—between second perigee and second apogee.

Out-of-plane corrections by either the spacecraft or target vehicle are performed at the nodal crossing of the two planes to drive the wedge angle to zero, which makes the two orbits coplanar.

"Velocity is a critical factor," Tindall said. A dispersion of only two feet per second can change altitude by one nautical mile. However, both plans can easily absorb booster underspeed or overspeed conditions at an acceptable insertion.

Each plan has an intermediate orbit to adjust for launch dispersions. Here, proper phasing of the two vehicles can be "timed" by establishing orbits with either high or low "catch up" rates to make the final orbit before rendezvous occur according to plan. (The spacecraft has up to 110 fps $\triangle V$ allotted for making phase changes).

The final approach is "standardized," therefore, with all launch dispersions, early or late lift-offs, and small thrusting errors by the spacecrafts, corrected and out of the way.

● **Out-of-plane problem**—Both plans are sensitive to large out-of-plane conditions. The spacecraft can use up to 240 fps of $\triangle V$ to make a plane change, "about a half of a degree maximum," Aldrin said.

Plane changes beyond the spacecraft's capability can be made by booster yaw steering or by the *Agena,* controlled from the ground, to drive the *Agena*'s plane into coincidence with that of the spacecraft.

While the initial trajectory of the spacecraft can be modified several times during the tangential method, the point of interception must occur at an apogee of the spacecraft's orbit. Thus, the rendezvous is "committed" to a fixed position in space, Tindall said.

● **Sun sighting crucial**—This also means that the position of the Sun can be critical and must be plotted for its location during the spacecraft's final approach to avoid having the Sun behind the target. The final adjustments of the rendezvous maneuver, and the docking, are performed visually.

During *MA-9,* Maj. L. Gordon Cooper, Jr. described the Sun as a "bluish-white, arc-like glob." He found looking at the Sun "quite difficult." "On one experiment, I tried to track into it. I almost went blind," Cooper said.

The rendezvous lighting conditions may limit the selection of launch windows when the tangential method is used.

Aldrin explained some advantages of the concentric plan:

"The spacecraft can delay committing the final approach until all the terminal nominal values are reached."

The start of the final maneuver can be held back until the best lighting conditions prevail, until an inertial background (star field) appears, until the spacecraft is over a tracking station, or perhaps until all three conditions exist.

Also, the pilot can pace all the optimum conditions to occur at the nodal point of the two planes, where he can correct for previous plane errors, if necessary.

The price for this flexibility is a higher $\triangle V$. Not a minimum energy or Hohmann transfer, the final maneuver is a direct thrust beginning 150 degrees back from the rendezvous point.

On the other hand, the pilot has the advantage in that he can keep his line-of-sight to the target more nearly constant against a sky background as the spacecraft approaches the *Agena.*

● **Tangential rendezvous problems**—The tangential method is more prone to errors. About 270 degrees of orbital travel from the rendezvous point, the computer will begin a series of computations using the Clohessy-Wiltshire equations of relative motions modified to give five points for corrections by thrusting prior to rendezvous. The first and largest thrust is at 270°. Smaller thrusts are made every 60° of orbital travel (210°, 150°, 90°, and 30°).

The target becomes visible to the pilot after the last correction at 30°.

(Continued on p. 32)



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During the semi-optical phase, the spacecraft will approach the target from ahead and slightly below, and the final braking maneuver is also the required $\triangle V$ addition to his velocity vector to circularize at 161 n. mi.

An altitude discrepancy at the spacecraft's apogee (the point of tangency) may not be detectable until the final moments of closure. The braking rate for the tangential trajectory is about 46 fps of $\triangle V$ (55 fps for the concentric method), and an altitude correction added to it may be very costly in fuel.

If the spacecraft moves up through the *Agena's* orbit, the pilot may be left with no "feeling" for determining his errors visually. His line-of-sight may rotate rapidly across the celestial references in the sky, and may even present him with a black Earth background during darkness.

● **Demanding on astronauts**—The final maneuver in the tangential method demands more piloting skill than in the concentric method. The spacecraft approaches the target from beneath in pitched-up attitude to keep the target visible in the window, and to keep the radar "locked on" the target.

As the spacecraft moves closer behind and below the *Agena,* it begins to climb up to the target's altitude. The pilot must apply a roll while in pitched-up position to yaw 180 degrees. This maneuver moves him in front of the target and facing it as he applies braking thrust. The target will appear to approach the spacecraft from the opposite direction to the velocity vector.

To increase the number and length of launch windows, the *Agena* may be launched into an inclination angle of 28.87°.

The plane of the target at launch will cross directly over Cape Kennedy. As the Earth rotates eastward, this plane will pass north of the Cape, aligning itself parallel to the direction of the spacecraft at it insertion, and about 0.4 degrees (30 mi.) between the planes at anti-nodal points.

The Earth will rotate the Cape position directly under the plane of the target approximately 101.5 min. after target launch. During this time, the target will have traveled once around in its orbit and will be in a favorable position to be intercepted by the spacecraft not only in its plane, but also in phase.

● **Timing important**—However, this condition persists for only 12 min., because with farther eastern rotation of the Earth, an out-of-plane condition builds up beyond the corrective capability of the spacecraft. The "window" can be expanded only by booster yaw steering or by *Agena* maneuvering from the ground.

Values can be "cranked" into the booster as late as five minutes before launch; however, MSC feels that juggling launch equations so late in the count may be avoided in the interest of safety.

On subsequent days, the plane of the target comes within 0.4 degrees of the launch pad—first south of it, then north, then south again at varying angles to it—for an unbroken period of about two hours.

To insert the spacecraft parallel to the target plane during this period, the booster has a "working azimuth" of from 82 degrees to 110 degrees from the pad.

The plane of the target precesses and the point where it crosses the equator regresses (moves westward) due to angular momentum coupling between the Earth's motion around the Sun and the target's orbital rate.

This factor, added to the change in the Sun's position of about 1 degree per day, causes the window to appear approximately one-half hour earlier on each successive day.

For this reason, launch operations begin late in the afternoon—about 4 p.m.—to take the greatest advantage of daylight on each subsequent day after target launch.

Some daylight is left in reserve for rescue operations in the event the mission is aborted during the boosted phase prior to sapecraft orbital insertion.

● **Early hookup desired**—MSC is looking into the possibility of rendezvous sooner than four orbits, but later than in a "direct ascent" trajectory rendezvous. "An earlier rendezvous would keep the vehicles over the tracking network, and could be completed before onboard (spacecraft and *Agena*) systems began to degrade," Tindall said.

This method would impose time-critical tracking on ground crews and equipment, Tindall said.

He explained: The first corrective action would take place at the first apogee, approximately 45 min. after the spacecraft is inserted into orbit. This would give ground personnel only half an orbit to determine the spacecraft's orbital parameters.

Post-rendezvous plans for the *Agena,* after the safe re-entry of the spacecraft, include a rendezvous with a "phantom orbit," simulated by ground computers, to exercise flight controllers and to thoroughly check out the *Agena* ground command system.

Melvin F. Brooks of MSC's Flight Operations Division said the *Agena's* main propulsion system would be lighted to make plane changes of "several degrees" and eccentric orbits with a high apogee and long period, commonly referred to as "dwell orbits." ■

Symposium Stresses Data Compression

by Rex Pay

LAS VEGAS, NEV.—A real-time speech communications link that requires only 10-cps bandwidth, cutting transmitted power from a deep-space probe by over six kilowatts to 64 watts, was described at the International Space Electronics Symposium here.

At the exhibition that accompanied the four-day symposium, a spacecraft data-compression system that cuts telemetry bandwidth by 22 to 1 was displayed.

Both developments represent answers to a current problem in communications discussed by speakers at the symposium: too much redundant information is being transmitted from space vehicles, taking up excessive bandwidth and power.

About 500 attendees were expected at the symposium, sponsored by the Institute of Electrical and Electronics Engineers' Space Electronics and Telemetry Group. About 100 attended the first session to hear invited papers.

Two opposing views on data compression were expressed. Systems engineers looked to it as the best way to reduce the power needed for transmitting information over megamile distances. Experimental scientists were less enthusiastic. They were willing to accept much redundant information if this meant that any unexpected deviation could be looked at in detail.

● **Hearing research**—The high data compression achieved in reducing normal speech to a bandwidth of 10 cps is the outcome of research on human hearing carried out by Santa Rita Technology, Inc., Menlo Park, Calif. Supported by the Aerospace Medical Div., USAF, and the U.S. Dept. of State, the development stemmed from recognition of the fact that the brain responds to rather slowly varying neural inputs.

In the system developed, speech is processed by a device that is an electronic representation of the human ear. This yields a signal of 10 cps bandwidth analogous to that received by the brain. At the receiving terminal, the signal is reprocessed to yield synthetic speech.

The resulting words are whispered and lack qualities such as accent, inflection and changing pitch. The only clue to the state of the speaker sending the message, apart from its verbal content, is in the timing of the words.

E. D. Hill of SRT said that laboratory models of the spacecraft unit required a volume of about 50 cu. in., weighed about one pound and consumed 0.7 watt, using transistor circuitry. This would enable an acceptable speech signal to be transmitted over a range of 100 million n. mi., using a transmitted power of 64 watts.

The physiological function of the outer and middle ear can be duplicated electronically by a bandpass filter and matching network. The cochlea and basiliar membrane can be simulated by a delay line with detectors tapped along its length. At any given instant of time, a constant sound entering such a system generates a pattern of voltages something like a spectrum of the sound.

The main feature of importance in the pattern, from the point of view of intelligibility, is in its average position along the delay line. This can be indicated by two parameters: the centroid of the pattern and its total area. For the fluctuating sounds of speech, the way that the centroid and area vary carries the bulk of the intelligence in the message. In fact, centroid and area waveforms for a given sentence look very much the same, whoever is talking.

● **Ship compressor**—The spacecraft telemetry compressor exhibited at the symposium was developed by Lockheed Missiles & Space Co. for NASA-Huntsville under a three-year contract amounting to about $500,000.

The compressor is designed to handle typical *Saturn* vehicle telemetry and may be flown after laboratory evaluation. It is designed primarily for use in deep space probes.

It is a zero-order predictor, weighs about 40 lbs., and occupies 1,800 cu. in. Logic operations are carried out by 467 integrated circuits, while 24,000 ferrite cores provide data storage.

LMSC has recently been awarded a study contract from NASA-Goddard to explore data-compression techniques for vehicle and ground telemetry. Company-funded tests on *Tiros* video data have shown that a bandwidth compression of 5.2 to one has little effect on the pictures; they remain suitable for meteorological interpretation. ■

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Giant solid-fuel rocket motor test launches a new 250,000-psi steel

The test firing of the first 156-in. solid-fuel rocket motor went through without a hitch at Lockheed Propulsion Company's test ground recently. There were no long countdowns. An engineer just pushed a button. Flame and smoke shot up with a terrific roar—and, in 109 seconds, the test was successfully completed.

In reality, this test marked the launching of the new USS Maraging Steel which was used in the rocket motor. This 18% nickel-cobalt-molybdenum steel series develops useful yield strengths of 200,000 to 340,000 psi—and it's the toughest steel ever made at these strength levels. Plates only $\frac{3}{8}$″ thick were used for the motor which developed a maximum thrust of more than a million pounds. In a subsequent hydrostatic test at pressures even higher than experienced during the firing, the maraging steel case proved to be in perfect condition. It will be used again in a later test firing.

The ultra-high strength levels of USS Maraging Steels are developed by an anneal followed by aging at 900°F for three hours—no quenching. The aging induces a hardening reaction in the steel's martensitic structure, retaining ductility and good toughness. There is practically no distortion during aging. Both annealed and hardened maraging steel can be welded without preheating. If welded in the aged condition, subsequent localized aging of the weld zone produces high joint efficiencies. Hot and cold working properties before maraging are excellent.

Outstanding facts about USS Maraging Steel

- Useful yield strengths up to 340,000 psi
- High ductility: 30% to 55% reduction of area
- Toughness: Charpy impact values typically 16 ft.-lbs. at −420°F
- Excellent dimensional stability
- Resistance to crack growth
- Resistance to stress corrosion
- Good weldability without preheating
- Good formability and machinability
- Freedom from decarburization
- Through hardening without quenching

United States Steel, through an extensive research program, has brought maraging steel into large-scale production. This program is designed to provide gigantic solid-propellent space booster motors having a gross thrust of 4 to 12 million pounds in sizes from 156″ to 260″ diameter and 60′ to 120′ long. Maraging steel simplifies fabrication problems and eliminates the need for huge heat-treating furnaces.

Availability. Air-melted USS Maraging Steel is available in a full range of plates, sheets, bars, strip, and forging billets.

Applications. Rocket motors, aircraft landing gear, extrusion dies, heavy-duty gears, machined parts, springs, tools, hull plates, structural assemblies.

Write for new booklet, USS Maraging Steels, United States Steel, Room 7633, 525 William Penn Place, Pittsburgh, Pa. 15230. *USS is a registered trademark.*

United States Steel USS

Nickel Alloy Rings for 260-in. Solid Program Impose Stringent Standards

Roll-forged components, furnished by Ladish Co., now being welded to Aerojet-General's half-length demonstration motor

by John F. Judge

THE LARGEST seamless rolled rings produced to date for rocket applications are being welded into the massive maraging steel motor case of the Aerojet-General Corp. half-length 260-in.-dia. demonstration solid rocket.

The huge components were fabricated by Ladish Co., Cudahy, Wis., using their roll forging techniques.

These 18% nickel alloy rings, ranging in size from 110 to 260 in. in diameter, will be used in the 260-in., solid-propellant rocket feasibility demonstration program sponsored by the Air Force Space Systems Div. The rockets, which will develop 3 million lbs. thrust, are scheduled to be test fired in 1965.

The 260-in. x 80-ft. rocket motor requires a set of six forged rings for motor case and nozzle shell components. To produce these massive rings, Ladish Co. required vacuum-arc-remelted material of a maximum combination of currently available size and weight.

Ingots weighing approximately 26,000 lbs. each were furnished by Republic Steel Corp. to stringent quality standards of soundness, cleanliness and structural and compositional homogeneity.

A test ring parted from each parent ring upon completion of forging operations was used to determine the appropriate solution annealing treatment. Additional test ring material removed after processing provided a thorough assessment of mechanical properties and microstructure resulting from deformation and thermal treatment sequences.

Ultrasonic inspection after forging and thermal treatment revealed no sonic indications, even when tested to a 3/64-in. standard—substantially exceeding specification requirements.

● **Clean ingots**—The specified material is "200-grade" maraging steel with a 0.2% offset yield strength of 200,000 to 235,000 psi after appropriate hot working and thermal treatment. The high quality and integrity requirements of the product necessitated the use of the vacuum arc remelting process.

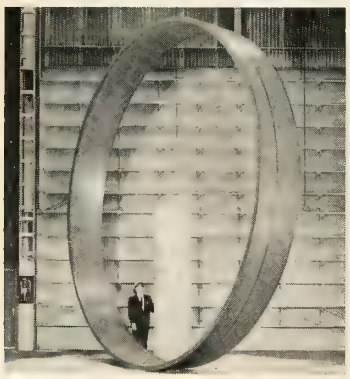
While vacuum-consumable-electrode remelting is not necessarily a mill requirement for the lower yield strength grades of maraging steel, several considerations make the selection of vacuum arc remelting appropriate for this type of application. Research has shown that vacuum remelting enhances fracture toughness properties and crack propagation resistance in high-strength structural materials.

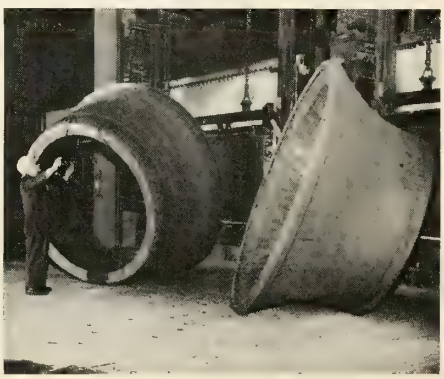
In addition, research performed by Ladish Co. has shown that vacuum arc remelting significantly increases transverse ductility and toughness. This is particularly important in connection with the forward and aft Y-rings. These rings require optimum properties in the short transverse direction. Good transverse properties are especially important at the junction of the "Y" machined into these rings.

The existence of laminations or parallel bands could result in metal separation and increased risk of failure at this location. Vacuum arc remelting reduces alloy segregation through controlled and progressive solidification of the ingot, resulting in a uniform structure virtually free of laminations.

A series of forging operations was required to convert the as-cast ingot into a mammoth seamless ring possess-

PHOTOS SHOW forward Y-ring (left), 110-in.-dia. exit flange and throat forgings (center) and nozzle throat forging (right).







ing a wrought, uniformly fine-grained microstructure capable of developing optimum properties during thermal treatment.

The Ladish Ring Roll, on which these rings are produced, can turn out seamless rings as large as 24 ft. across and up to a 6-ft. face height.

After rolling to maximum diameter, rings were annealed in a furnace with a 25-ft.-square hearth. The annealing cycle was based on information developed during the evaluation of the test ring material. Both the forward and aft Y-rings are machined on a 28-ft. vertical mill easily capable of accommodating the largest rings produced.

In addition to the 260-in. Y-rings, Ladish Co. also produces the 191-in.-dia. aft flange of the motor case, and the entrance flange, throat forging, and exit flange of the nozzle shell.

Finish machining of other surfaces of these parts is accomplished after incorporation with rocket components fabricated by another Aerojet-General subcontractor, Sun Shipbuilding & Dry Dock Co.

Efforts such as the development of critical components forged from maraging steel for the 260-in. rocket involve both new concepts and new materials.

As a consequence, such efforts often require thousands of engineering manhours for material evaluation and forging research prior to award of any production contracts. For example, maraging steel rings in sizes from 24 to 70 in. were produced using stock sizes starting with 6-in. billet stock as prototype evaluation prior to the full-scale effort. Data so developed provided information concerning the response of maraging steels to forging and heat-treating.

Some of the conclusions from this research effort were:

—Tensile, impact, fracture toughness, and microstructure evaluations show that selecting the proper solution annealing temperature is vital to developing the desired, fine, recrystallized grain structure. Another consideration is the range of annealing temperature and the selection of the optimum temperature in relation to the forging reduction and thermal processing cycle employed.

—In achieving specified mechanical properties, a portion of the forging reduction must be performed at the low end of the forging temperature range. This necessitates the additional power provided by heavier equipment.

The feasibility study rocket into which the Ladish Co. forged rings will be assembled is designed to provide a thrust of approximately 3-million lbs. Successful static firing tests of this type of case are expected to result in eventual production of a 7-million-lb.-thrust, full-length rocket. ■



Circle No. 9 on Subscriber Service Card

ENGINEERS:

Design and Development openings at Boeing

Boeing, world leader in advanced swept-wing, multi-jet aircraft, is today pioneering evolutionary advances in both civilian and military aircraft fields. These programs have created outstanding openings for graduate engineers at all experience levels in the fields listed below. Minimum educational requirement is a B.S. degree in an engineering discipline, except where noted.

DESIGN

Structural—Duties include the determination of aircraft structural requirements, preliminary sketches and preparation of final layout drawings and investigation.

Hydraulic—Duties include design of hydraulic systems and hydraulically actuated mechanisms, including brake-flaps, spoilers, landing gear doors, landing gear and nose wheel mechanisms.

Air Conditioning & Pneumatic Systems—Positions include the design of air conditioning and pneumatic systems, cabin heating and ventilation, cabin pressurization, electronic equipment cooling, and temperature control of aircraft surfaces.

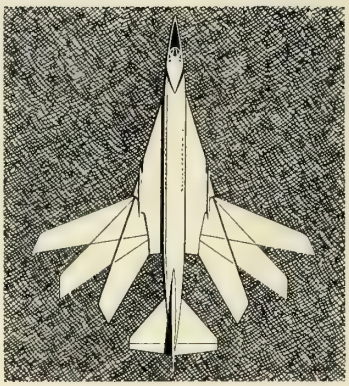
Aircraft Control—Duties involve design of controls including ailerons, elevators, rudder, trim tabs and engine controls.

Power Plant—Assignments involve the design of engine installations, engine accessories, strut and engine supports, engine nacelles, and thrust reversers / sound suppressors.

Fuel Systems—Positions include design of fuel systems, fuel and tank ventilation systems, water injection and tank purging systems.

DEVELOPMENT

Structural Dynamics—Duties involve analysis and experiments in aeroelastic fields of flutter and dynamic loads. B.S.



or advanced degree required in applied mechanics with significant aerodynamic and structures background related to high-speed aircraft. Should be familiar with latest theories and techniques for analysis and test.

Stability and Control—Openings require strong background in airplane flight control system design and analysis, and stability and control characteristics, plus knowledge of computers, servomechanism design and development and testing of airplane configurations. Master's degree or equivalent.

Flight Control Systems—Positions involve establishing dynamic design criteria and specifications for flight control systems, subsystems and components; selection of most suitable control system components, and guidance of control system procurement and flight test. Requires B.S. or M.S. in engineering, mathematics or physics with applicable experience.

Metallurgy and Mechanical Engineering—Assignments entail alloy selection and application, development and improvement of processes, preparation of specifications, laboratory experiments, technical consultation, and service failure analysis. Requirements, in addition to experience in aircraft technology or a related field, include familiarity with the electron microprobe and microscope and standard metallurgical equipment.

Chemical Engineering—Openings require experience in lubrication materials and concepts; elastomeric, inorganic finish, and organic polymeric materials, and structural adhesive bonding, plus a basic knowledge of materials behavior. Work involves evaluation, analysis and investigation of all materials characteristics, including mechanical, electrical, chemical and surface.

Propulsion—Responsibilities include research and development, primarily V / STOL oriented, in the fields of subsonic and supersonic inlets, thrusting ejectors and engine fan thrust vectoring; engine cycle analysis, engine / airplane optimization studies for subsonic and supersonic propulsion systems, and VTOL propulsion technology.

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AIRPLANE DIVISION

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The Industry Week

Mergers and Acquisitions

Systron-Donner Corp., Concord, Calif., manufacturer of digital counting and timing equipment, analog computers, data handling equipment, accelerometers, gyroscopes and flight control instruments, has acquired the business and assets of Hyperion Industries, Inc., Watertown, Mass. Hyperion produces data retrieval equipment, timing systems, digital data processing instrumentation and solid-state power supplies. Under terms of the acquisition, the original owner-management remains with Hyperion and operations are to continue in that firm's present location. . . . *Guide Manufacturing Co., Sun Valley, Calif., has begun negotiations with four affiliates, E.J.S. Machine, Guide Microwave, Systems Design, Inc., and Aero Devices Co. The firm's board of directors have approved the plan, and if accepted by stockholders, the merger will occur this month.* . . . Control Data Corp., Minneapolis, has reached preliminary agreement with TRG, Inc., on terms of CD's acquisition of TRG. Specialties of TRG are in electro-optics and quantum electronics, microwave electro-mechanics, sonar systems and naval hydrodynamics. Sale remains subject to final approval of both boards of directors and stockholders of TRG. . . . *The name of Fairchild Stratos Corp. has been officially changed to Fairchild Hiller Corp. Hiller Aircraft Co., Inc., became a Fairchild subsidiary last May.* . . . Mesa Scientific Corp., Inglewood, Calif., has merged with Systems Programming Corp. of Santa Ana, Calif. Both Mesa and Systems Programming are computer software firms. . . . *Cubic Corp., San Diego, Calif., has acquired Waddell Dynamics, Inc., also of San Diego. Move was to expand Cubic's line of proprietary products and markets, particularly in the area of anti-submarine warfare. The newly acquired firm will operate as an independent subsidiary of Cubic specializing in underwater electronic technology.* . . . Industry Week erroneously stated in an item Aug. 31 on the acquisition of Pierce-West, Inc., by The Bendix Corp. that Pierce-West would "become the Micrometrical Div. of Bendix." Actually, Bendix has had a Micrometrical Div. for some time, and Pierce-West is merely to become a plant within that division.

New Activities

Lockheed Missiles & Space Co. has formed a Manned Space Programs organization to be headed by Harold T. Luskin, former NASA program chief for Lockheed. Luskin will report directly to Vice President R. R. Kearton, who is general manager of Lockheed's Space Systems Div., and to Gladyn H. Putt, vice president directly responsible for manned space programs in the Space Systems Div. The new organization is intended to increase the effectiveness of both LMSC and Lockheed's California Co. in the manned space field. . . . *Honeywell, Inc.'s military products facility in Boston has expanded its scientific work beyond the electro-optics field to include R&D in radar and other applications of high-frequency energy. The facility will be called the Honeywell Radiation Center to more properly reflect its expanded activities.* . . . Kaiser Industries Corp., Oakland, Calif., has re-consolidated the domestic and international operation of Kaiser Engineers into one division. Upon consolidation, Kaiser Engineers will be one of the largest engineering-construction firms in the world. KE is engaged in work on such diverse projects as construction of NASA's space propulsion facility and integrated mission control center, and aluminum reduction in Ghana, Africa.

Long Island Ponders Industry Plight

A study conducted at Columbia University has concluded that ". . . the economy of Nassau and Suffolk counties (Long Island, N.Y.) is so closely keyed to defense spending that even a reallocation of military contracts could cause economic chaos throughout the island." Alfred Wood, an industrial engineer with the Columbia Broadcasting System and author of the study, found that 50.1% of the manufacturing jobs in the two counties are related to defense procurement. This compares with 5.0% in that category in New York State as a whole and an overall 7.4% in the nation. Wood has called for special attention to the problem posed to the area by any possible loss of future defense work.

Sperry Rand Loses Patent Suit

Texas Instruments, Inc., Dallas, has prevailed in a patent infringement suit brought against it by the Sperry Rand Corp. The United States Court of Appeals for the Fifth Circuit has upheld an earlier ruling of the United States District Court for the Northern District of Texas in favor of TI in the suit filed against it in September, 1959. Sperry Rand alleged that all germanium semiconductor devices manufactured by TI infringed upon a patent granted to Sperry Rand in 1950.

Missile/Space Facilities

Simonds Precision Products, Inc., Vergennes, Vt., last week formally dedicated a new 28,00-sq.-ft. addition to its main plant. The wing includes 20,000 sq. ft. of special environmentally controlled area for assembly and testing of electronic systems to be incorporated in space vehicles, satellites, missiles and high performance aircraft. . . . *The Army's Picatinny Arsenal has dedicated a new $1-million laboratory building named in honor of a former Arsenal Commander, Brig. Gen. Norman F. Ramsey, who died last year. The Ramsey Building will provide a modern facility for examining and testing munitions parts.* . . . Moore Special Tool Co., Inc., Bridgeport, Conn., precision machine tool manufacturer has opened a new Measuring Machine Laboratory. Up to 48 machines a year will be produced in the new facility, with as many as 10 in process at any one time.

AIR FORCE

$21,000,000—**The Boeing Co.,** Seattle, for continued work on the *Minuteman* ICBM.

$3,405,498—**Emerson Electric Co.,** St. Louis, addition to existing contract to make automatic test equipment for communications and navigation systems.

$2,350,000—**Litton Industries, Inc.,** Woodland Hills, Calif., addition to contract for equipment to overhaul and test inertial navigation systems.

$2,000,000—**General Motors Corp.,** AC Spark Plug Div., Milwaukee, Wis., for R&D work on an inertial guidance system for the *Titan II* missile.

$1,600,000—**Avco Corp.,** Wilmington, Mass., for work on a classified project.

$1,500,000—**Honeywell Inc.,** Washington, D.C., for delivery of eight electronic data processing systems to major air command headquarters.

$1,500,000—**North American Aviation Inc.,** Tulsa, Okla., for production of modification kits for *Hound Dog* missiles.

$1,001,044—**Lockheed Aircraft Corp.,** Sunnyvale, Calif., for repairs to *Agena D* rocket boosters.

$785,962—**United Aircraft Corp.,** United Technology Center, Sunnyvale, Calif., for integrated research effort on high-energy hybrid propellants.

$750,000—**Varian Associates,** Bomac Div., Beverly, Mass., for magnetrons.

$360,000—**General Dynamics Corp.,** Astronautics Div., San Diego, Calif., for cryogenic tankage integrity program.

$250,000—**Johns Hopkins University,** Baltimore, for research to determine the atmosphere of Mars and Venus by balloon astronomy.

$161,629—**Aerojet-General Corp.,** Solid Rocket plant, Sacramento, Calif., for continuation of propellant liner bonding investigations. Also $68,739 for orientation and indoctrination in rocket production and production processes.

$151,455—**Avco Corp.,** Research and Advanced Development Div., Wilmington, Mass., for development of manufacturing methods for the production of infiltrated tungsten composite rocket nozzle inserts.

$100,000—**Polytechnic Institute of Brooklyn,** Brooklyn, N.Y., for continuation of research on high-frequency oscillatory combustion.

North American Aviation, Autonetics Div., Anaheim, Calif., for a study of forging techniques to make beryllium a more useful metal (amount undisclosed).

Allis-Chalmers, Research Div., Milwaukee, Wis., for a study of fuel cell power supply requirements for the *Manned Orbiting Laboratory* program (amount undisclosed).

Ball Brothers Research Corp., Boulder, Colo., to design and construct a high-altitude balloon-borne biaxial solar tracker to search and track the Sun in order to make studies that cannot be made from the ground.

ARMY

$31,381,167—**Philco Corp.,** Communications and Electronic Div., Ft. Monmouth, N.J., to provide 10 overseas installations for AUTODIN (Automatic Digital Network).

$23,188,823—**Martin Co.,** Orlando Div., Orlando, Fla., for two contracts for industrial engineering and R&D services on the *Pershing* weapon system. The second contract, $987,893, covers R&D services on *Pershing*.

$8,929,175—**Raytheon Co.,** Lexington, Mass., to continue engineering services on the *Hawk* anti-aircraft missile system.

$6,700,000—**Sperry Rand Corp.,** Sperry Utah Div., Salt Lake City, for continued work on the *Sergeant* missile system.

$3,000,000—**Philco Corp.,** Newport Beach, Calif., incremental funding for *Shillelagh* R&D.

$2,720,000—**McDonnell Aircraft Co.,** St. Louis, for exploratory development effort on a *Medium Assault Anti-tank Weapon* (*MAW*), a tube-launched, wire-guided missile.

$2,641,430—**Akwa-Downey Construction Co.,** Milwaukee, Wis., for two additional buildings for working on the fuel systems in the three-man *Apollo* spacecraft.

$1,749,000—**North American Aviation, Inc.,** Columbus, Ohio, for advanced development work on the *Redhead Roadrunner* target drome.

$1,307,077—**Raytheon Co.,** Lexington, Mass., for work on a target system for the *Hawk* missile.

$750,000—**Johnson Service Co.,** Systems and Engineering Construction Div., Milwaukee, Wis., for modification work on antenna silos at 10 USAF *Atlas F* and *Titan II* missile bases.

$427,749—**Bucon, Inc.,** Cape Canaveral, Fla., to build a Deep Space Instrumentation building at Cape Kennedy for use in Project *Apollo* and unmanned spacecraft programs.

NAVY

$9,573,525—**Lockheed Missiles & Space Co.,** Sunnyvale, Calif., for tactical field engineering support for the *Polaris* missile.

$5,115,448—**Insterstate Electronics Corp.,** Anaheim, Calif., for *Polaris* missile instrumentation.

$3,429,914—**Chromcraft Corp.,** St. Louis, for LAU-3 rocket launchers.

$2,507,807—**General Electric Co.,** Pittsfield, Mass., for work on the *Polaris* missile.

$1,466,632—**Cleveland Pneumatic Tool Co.,** Cleveland, for loading equipment for the transfer at sea of missiles and other loads.

$400,000—**General Dynamics Corp.,** Stromberg-Carlson (div.), San Diego, Calif., for special airborne computer display equipment for use in development of new ASW techniques.

$170,398—**Avco Corp.,** Ordnance Div., Richmond, Ind., for *Polaris* facilities.

$100,000—**Cornell Aeronautical Laboratory,** Buffalo, N.Y., to study proposed air seacraft weapons systems for future ASW operations.

NASA

$5,000,000—**Sanders Associates Inc.,** Nashua, N.H., to provide seven systems to display information for checkout and launch of *Saturn V* space vehicles.

$2,800,000—**The Bendix Corp.,** Detroit, a three-year contract to furnish launch support services at Kennedy Space Center. Total cost may reach $17 million.

$2,500,000—**Reeves Instrument Co.,** Long Island City, N.Y., for three 30-ft. unified S-band antenna systems for tracking *Apollo* spacecraft.

$1,600,000—**Lear Siegler, Inc.,** Santa Monica, Calif.,—three new follow-on contracts for the expansion and modification of NASA's Space Flight Center test facilities.

$996,000—**North American Aviation,** Rocketdyne Div., Canoga Park, Calif., for performance of analytical and experimental studies of advanced LOX/LH2 propulsion.

$689,000—**Avco Corp.,** Tulsa, Okla., Div., for ultra-high vacuum chamber.

Westinghouse Electric Corp., Defense and Space Center, Baltimore, to provide mechanical and electrical systems integration and launch support services for the *Interplanatary Monitoring Platform* (*IMP-E*) satellite (amount undisclosed).

INDUSTRY

$8,000,000—**Texas Instruments, Inc.,** Dallas, from **McDonnell Aircraft Corp.,** St. Louis, to continue production of infrared equipment used in Air Force and Navy versions of Phantom II plane.

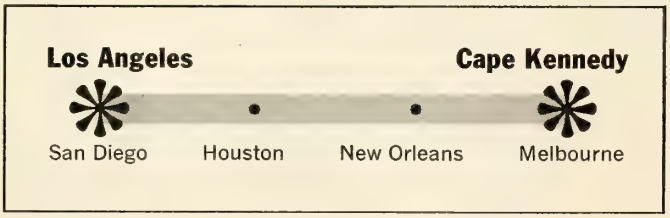
$1,500,000—**United Aircraft Products, Inc.,** Dayton, Ohio, from **General Electric Co.,** New York City, for equipment to be used in the F4 Phantom program.

$1,000,000—**Remanco, Inc.,** Santa Monica, Calif., from **North American Aviation, Inc.,** Space and Information Systems Div., Downey, Calif., for development and fabrication of test and checkout equipment for *Apollo* spacecraft service module engine.

$800,000—**Bendix Corp.,** Eclipse-Pioneer Div., Teterboro, N.Y., from **The Boeing Co.,** Seattle, for electronic equipment for the *Minuteman* improvement program.

$787,000—**Martin Co.,** Baltimore, from **The Boeing Co.,** Seattle, for storage for helium to be used to pressurize the huge fuel tanks on the first stage of the *Saturn V* Moon rocket.

What's the shortest distance between these 2 points?



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Is this any way to run an airline? You bet it is.

Jet National
coast to coast to coast

Circle No. 10 on Subscriber Service Card

New Product of the Week:

Physiological Monitor

Spacelabs, Inc., is offering a system of physiological instrumentation capable of maintaining a check on test subjects engaged in space flight research.

Designated the Model 130 Biotel, it provides the capability of monitoring up to eight physiological parameters using hardware or telemetry transmission. The system consists of modular building blocks that can be arranged in a variety of configurations.

The flexibility of the Biotel solves a problem in medical research by allowing the researcher to tailor a system to particular needs, the firm says. Modules are available for monitoring the electrocardiogram, respiration, electroencephalogram, temperature, electromyogram, galvanic skin response and voice, either singly or in combination.

Components include sensors, signal conditioners, transmitter, power supply and receiving station. The sensors, signal conditioners and transmitter can be



worn in a specially tailored vest. A handbook of operating instructions is supplied with the system.

Circle No. 151 on Subscriber Service Card

Kilovoltmeter

Industrial Instruments, Inc., has available a voltmeter ranging to 100,000v with a full scale dc accuracy of ±1% (±2% ac). The device is fully transistorized and features a 6-in. mirror scale meter.

Special voltage probes are supplied with the unit: one for the 5 and 10 kv ranges and one for the 50 and 100 kv ranges. Accuracy of the probes is ±2% for the lower ranges, ±4% for the higher. Accuracies to ±0.1% are possible with a standard divider accessory.

Circle No. 152 on Subscriber Service Card

Beta Irradiator

A strontium 90 beta irradiator designed to provide greater versatility and safety in radiation processing and allow a large absorbed dose of ionizing radiation in liquids and gases has been introduced by the 3M Company.

The unit weighs less than 500 lbs. and has a 28-year half-life isotope. It allows greater absorbed doses of ionizing radiation with less equipment and materials cost than possible with previous beta irradiators for the generation of free radicals, the firm says. Because of the low penetration of beta particles, need for extensive shielding is eliminated.

The unit consists of a pressure vessel with an arrangement of parallel tubes through which the material to be irradiated flows. SrY-90, in the form of small spherical ceramic particles, is packed around the tubes so that a uniform dose of radiation is applied. The 2.18 Mev betas have a high efficiency in producing free radicals or ionizing the material in the tubes. A total of 100 curies of SrY-90 will deliver a 1-megarad dose per hour to 50 grams of unit density material, the company says.

Circle No. 153 on Subscriber Service Card

Hardened Recorder

A radiation-hardened magnetic tape recorder/reproducer for rocket applications has been designed and developed by Astro-Science Corp., in cooperation with Sandia Corp.

Test results have indicated that the electronics will be capable of operation after subjection to radiation levels of 1×10^{14} nvt and a gamma dose rate of 1×10^{12} R/sec. The transport has been operated through an environment of 20 g's hardmounted vibration, 300 g's 3 ms shock and steady state 80 g acceleration.

Circle No. 154 on Subscriber Service Card

Differential Amplifier

An all-silicon differential operational amplifier with a common mode impedance exceeding 100 megohms is being marketed by Data Device Corp.

The Model D-16 has a differential input impedance of 5 megohms, a current drift under 1 nA/day at constant temperature, a current gain of 10 million and an open-loop voltage gain of more than 86 db. It has an offset current of less than 20 nA; total current drift with temperature is 15 nA from —25° to 85°C.

Circle No. 155 on Subscriber Service Card

Super-Heterodyne Receiver

Scientific-Atlanta, Inc., has available a super-heterodyne receiver which operates in the 20-mc to 100-gc region.

The Model 1640-SW features continuous sweeping of either of two octave bands (350 to 700 mc and 700 to 1,400 mc). Output voltage is 0 to 1v dc proportional to frequency for external recording. AGC output is proportional to the logarithm of a CW input signal (65-db dynamic range). Band pass preselection provides 80-db IF rejection, 80-db image rejection and combined manual and motorized tuning control.

Circle No. 156 on Subscriber Service Card

Gas Vapor Detector

An atmospheric condition indicator that detects and measures both combustible and toxic gases or vapors with a single indicating instrument is being marketed by Erdco Engineering Corp.

The portable Tox-Ex Model 01HCS has rechargeable batteries providing 8-hr. continuous power sampling. The unit has a dual-scale meter—an explosive scale which registers 0 to 100% of lower explosive limit and a toxic scale



which measures 0 to 1,000 parts/million. Three-second responses are achieved up to 23 ft. from the indicator. The unit measures 6.25 x 6.75 x 4.75 in. and weighs 10.25 lbs.

Circle No. 157 on Subscriber Service Card

missiles & rockets

BEYOND APOLLO—THE U.S. SPACE PROGRAM

MISSILES AND ROCKETS will publish its fourth annual NASA issue November 30, 1964. Now accepted as the authoritative publication on the nation's space agency, M/R will examine the National Aeronautics and Space Administration's current and future projects, people and facilities—plus NASA fiscal 1966 budget planning now being considered by the administration.

PUBLICATION DATE
NOVEMBER 30, 1964

ADVERTISING CLOSES
NOVEMBER 16, 1964

With major procurement f the Apollo manned lun landing program now behir it, NASA is deep in the pla ning of new projects to expar man's knowledge in spac Special emphasis is placed this issue on the U. S. Spac Program—BEYOND APOLL —with detailed descriptio of post-Apollo missions:

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Heat Transfer Compound

A grease-like silicone dielectric compound, said to have heat transfer properties three times those of silica-filled greases and about twice those of filled epoxy, has been developed by General Electric Co.'s Silicone Products Dept.

Insulgrease G-640 is an opaque material that exhibits less than 1% bleed and evaporation at 200°C after 24 hours. Typical thermal conductivity is 1.4 x 10^{-3} gm. cal/(sec.), (cm^2) (°C/cm). Used inside a semiconductor device case, G-640 protects the junction from shock and vibration.

Circle No. 158 on Subscriber Service Card

X-Y Recorder

F. L. Moseley Co. has introduced a basic systems X-Y recorder, said to be adaptable to almost any system requiring accurate X-Y readout at minimum cost.

The Model 7050A is a solid-state unit with servo amplifiers having single-ended inputs. Any desired single input span from 100 mv to 100v full scale, each axis, is available. Accuracy is 0.1% full scale. Zero setting is accomplished by a screwdriver adjustment; calibration is adjusted internally.

Circle No. 159 on Subscriber Service Card

Data Reduction System

A data reduction system, composed of a data viewer and an optional data scaler, is being marketed by Data Scaler. The system is designed for analyses of strip chart records up to 16 in. wide.

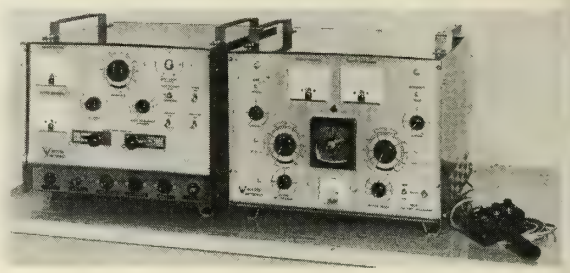
The data viewer is a console, 4 ft. x 4 ft. x 21 in. Records are held on ½-in. hex spindles at either end of the viewing area. They are transported in either direction at speeds from 0 to 500 fpm by an electrical drive.

The data scaler, which may be purchased separately or as an attachment, permits direct reading of records without the need of a calculator to correct for scale factors. The device can handle single or multiple channels, rectilinear and curvilinear records, linear and non-linear calibrations.

Circle No. 160 on Subscriber Service Card

Inert Gas Welder

A miniature inert gas welder with a range from 0.2 to 50 amps is available from Western Arctronics. The bench-



type unit is ideal for welding thin foils, delicate assemblies and fine wires, the firm maintains.

It can be used with either 115 or 230v with ac/dc current superimposed with high frequency for instantaneous starting. It can accommodate tungsten from 0.01 to 1/16 in. 2% thoriated. Other features include built-in RF starting control, remote or standard full linear control, a two-stage magnetic amplifier and a primary contactor and control transformer.

Circle No. 161 on Subscriber Service Card

Thermocouple Compensator

A thermocouple reference junction compensator adjustable over a 50°F span has been developed by Consolidated Ohmic Devices, Inc.

The Model JR-99 is epoxy-encapsulated and meets MIL-E-5272 specifications. Accuracy is ±0.25°F. Warm-up is instantaneous. The device is adjustable from 7° to 57°F, but any reference temperature adjustment range from −310° to 1,000°F is available on order.

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Radar Receiver

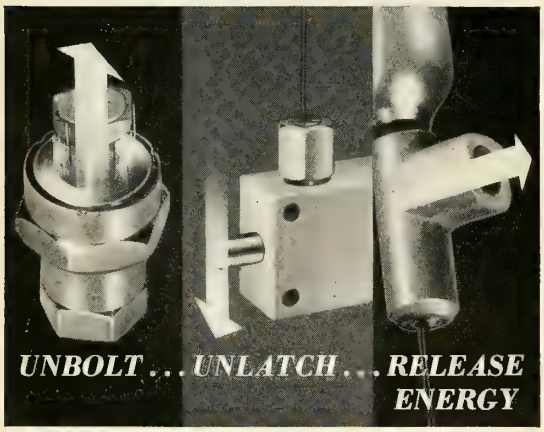
Aerospace Research, Inc., has announced a series of solid-state pulse receivers, designed for radar or backscatter application.

The Model PR-40 is a dual-channel unit in the 40-mc band. The unit features a specially designed IF amplifier at 5.2 mc that may be switched to linear or logarithmic operation. The precision attenuator covers a 55-db dynamic range. Sensitivity is 0.3 mv. Other receivers in the series cover a frequency range from 10 to 120 mc at various IF bandwidths.

Circle No. 163 on Subscriber Service Card

Torque/Balance Test System

A pulse torque-to-balance system for testing inertial components is available from Dynamics Research Corp. The system is designed for production and acceptance testing of inertial guidance and control components by pulse torquing methods. Chief applications extend to testing gyroscopes, accelerometers and inertial components having direct cur-



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rent torque generators, the firm says.

Advantages of the torque testing system over conventional testers include, the company says, the system's ability to simulate operating conditions during component testing, the flexibility of using modulated pulses for greater measurement accuracy, automatic printout of test results and the use of open or closed loop test modes.

Characteristics of the system are a stability of one part in 10^5 per 100 hours and a precision current source with a resolution of one part in 10^7. The precision current switch has a rise time of less than 50 nanosecs. with a stability of ±15 nanosecs. per 100 hours. The dual time generator with two independent time intervals has a setting from 10 to 99,999.8 microsecs., with a resolution of 0.2-microsec. intervals.

Circle No. 164 on Subscriber Service Card

Silicon Chopper

The Model 71 transformer-coupled chopper (or modulator), designed to alternately connect and disconnect a load from a signal source, is available from Solid State Electronics Corp.

The silicon transistor unit may also be used as a demodulator to convert ac to dc signals. It is capable of linearly switching or chopping voltages over a dynamic range which nominally extends from 1 mv to ±10 v. The contacts can handle up to 5 milliamps.

The unit has a built-in transformer-coupled isolating network so that it can be driven from an ac source common to the dc voltage being chopped. Sinusoidal or square wave drive may be used. Frequency range is 40 cps to 70 kc. Temperature range is −55° to 150°C.

Circle No. 165 on Subscriber Service Card

Variable Attenuator

DeMornay-Bonardi Div. of Datapulse, Inc., has available a variable attenuator with a range of 8.2 to 12.4 gc.

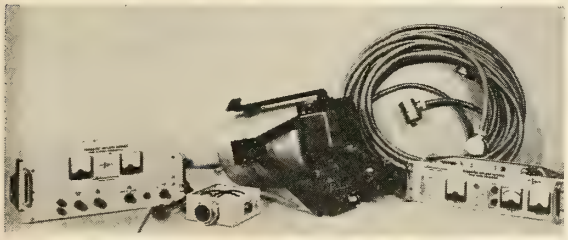
The Model DB 431 features 500-watt average power absorption, an initial insertion loss of 0.5 db for 50-db range and VSWR of less than 1.15:1. Optional attachments can extend the range to several kilowatts. Other features include a calibration accuracy of 0.3 db and anti-backlash mechanism.

Circle No. 166 on Subscriber Service Card

Parametric Amplifier

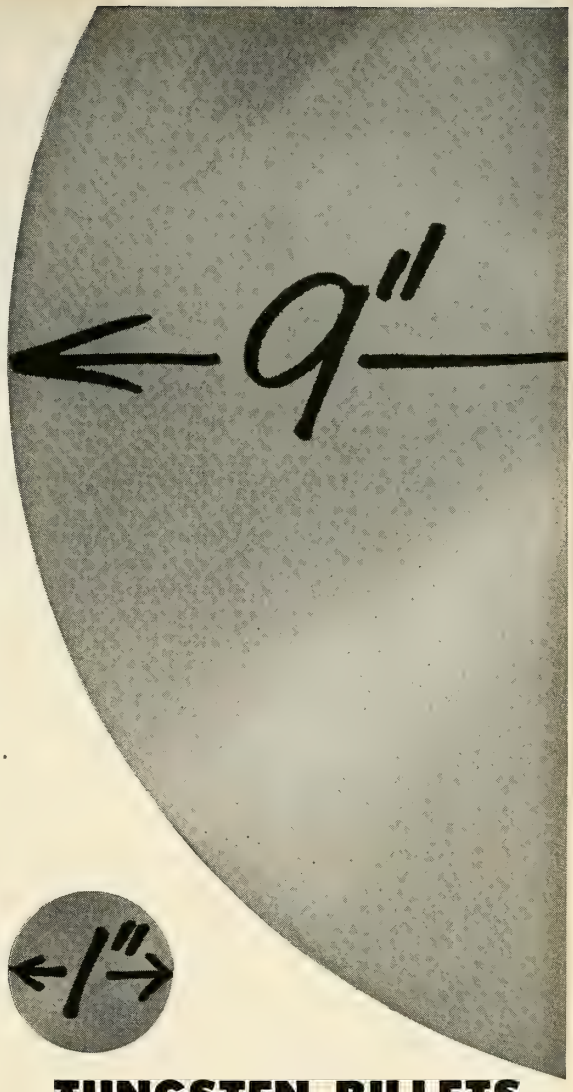
An X-band design parametric amplifier, designed primarily for radio astronomy, space communications or advanced radar applications, is being marketed by Microwave Physics Corp.

The X-14 was designed for 48-hr. operation on a single



charge of liquid nitrogen. It is supplied with a klystron power supply, parametric amplifier in a ±45-degree tiltable dewar and remote monitor with bias power supply. Signal frequency is 7.5—8.05 gc; gain is 15 db nominal; instantaneous bandwidth is 20 mc to 1.0 db points.

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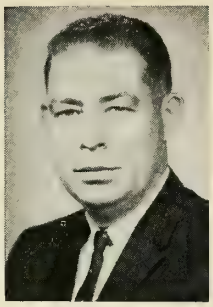
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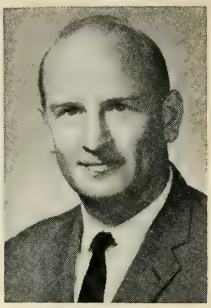
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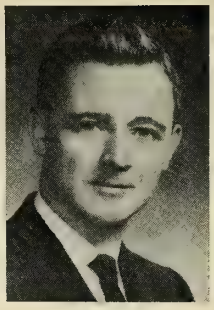
names in the news



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RILEY

Sylvania Electric Products, Inc., New York City, has formed an electronic components group to be headed by **Merle W. Kremer.** Kremer is a senior vice president of Sylvania. **Richard M. Osgood** was appointed vice president and general manager of the semiconductor division.

Leon L. Berman: Promoted to vice president-systems of American Electronic Laboratories, Inc., Colmar, Pa. Also promoted was **Iverson Korsen,** to the position of vice president-mechanical engineering.

John K. Hulm: Honored by the Franklin Institute of Philadelphia with its John Price Wetherill Medal in recognition of his discoveries in the field of cryogenics research. He is director of cryogenics research and development at Westinghouse Research Laboratories, Pittsburgh.

Marvin J. Levy: Named vice president in charge of operations at Belock Instrument Corp., College Point, N.Y. He was also appointed a member of the board of directors of Astro-Space Laboratories, a subsidiary of Belock, in Huntsville, Ala.

Hans Adami: Joined Rocket Research Corp., Seattle, as chief of mechanical design for monopropellant hydrazine rocket systems. He was formerly with The Boeing Co.

Howard H. Haglund: Named to the newly created post of deputy manager of the *Surveyor* spacecraft project at the Jet Propulsion Laboratory, California Institute of Technology and NASA, Pasadena, Calif. He was replaced as head of the Guidance and Control Div. by **John R. Scull.**

Harlowe J. Longfelder and **Robert E. Bateman:** Named to lead The Boeing Co.'s team working on the Air Force *Manned Orbital Laboratory (MOL)* program competition, in Seattle.

James F. Riley: Elected president of Signetics Corp., Sunnyvale, Calif. He was formerly with Corning Glass Works. Also named was **F. J. Van Poppelen, Jr.,** as vice president of marketing.

Robert S. Childs and **Michael Flaherty:** Elected vice presidents of The Bunker-Ramo Corp., Stamford, Conn. Childs will be vice president, field operations, and Flaherty will be vice president, manufacturing.

Dave Pandres, Jr.: Appointed to head the theoretical physics section of the Douglas Aircraft Co.'s corporate advanced research laboratory, Santa Monica, Calif. He is author of numerous scientific articles and an active researcher on the quantum and general relativity theories.

Lt. Col. Ballard B. Small: Named project manager of the U.S. Army's *TOW* missile system under the Army Missile Command, Redstone Arsenal, Ala.

Harold T. Luskin: Heading the new manned space programs division of Lockheed Missiles & Space Co., Sunnyvale, Calif. He formerly headed Lockeed's NASA programs.

Charles F. Adams: Elected chairman of the board of Raytheon Co., Lexington, Mass. Also elected was **Thomas L. Phillips,** as president of the company.

William R. Cummings: Has opened an office in Houston as Houston representative for Kollsman Instrument Corp., Syosset, N.Y. He was formerly with Ryan Aeronautical Co.

William G. Christmas: Made general manager of the York Div. of American Machine & Foundry Co., York, Pa. He was formerly in charge of engineering and administration.

Charles H. Berry: Appointed vice president of General Precision, Inc., Tarrytown, N.Y., and assigned as corporate manager of the company's Washington, D.C., office.

J. P. Ruina: Elected president of the Institute for Defense Analyses. He is on a leave of absense from his position as professor of electrical engineering at the Massachusetts Institute of Technology. Until July, 1963, he was assistant director for defense research and engineering in the office of the Secretary of Defense.

Charles H. Leithouser: Named director of administration for the Martin Co., Baltimore. He was previously with the Orlando division, where he was executive director of management operations.

—when and where

OCTOBER

Flight Mechanics and Entry Technology Meeting, sponsored by the AIAA and NASA, Convention Center, Williamsburg, Va., and Langley Field, Va. (meeting at Langley is classified), Oct. 12-13.

Second Symposium on Protection Against Radiations in Space, sponsored by AEC, NASA and the Air Force, Civic Auditorium, Gatlinburg, Tenn., Oct. 12-14.

Second Aerospace Nuclear Propulsion Conference (partly classified), sponsored by the American Nuclear Society, AIAA, Atomic Energy Commission, and NASA, Naval Postgraduate School, Monterey, Calif., Oct. 12-15.

19th Annual International Instrument-Automation Conference & Exhibit, sponsored by the Instrument Society of America, New York Coliseum, New York City, Oct. 12-15.

Symposium on Dosimetry in High Level Exposure, International Atomic Energy Agency, Vienna, Austria, Oct. 12-16.

Second Guidance Test Symposium, sponsored by the Air Force Missile Development Center, Holloman AFB, N.M., Oct. 13-14.

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34th Symposium on Shock, Vibration and Associated Environments (partially classified), sponsored by the Department of Defense (DDR&E), Fort Ord, Monterey Peninsula, Calif., Oct. 13-15.

19th Annual Midwest Quality Control and Aircraft and Missile Division Conference, sponsored by the Dallas-Ft. Worth Section of the American Society for Quality Control, Dallas, Oct. 15-17.

Aerospace Frontiers in New Mexico, sponsored by ASME and the University of New Mexico, Univ. of New Mexico, Albuquerque, Oct. 15-17.

Combined Analog-Digital (Hybrid) Simulation, sponsored by Control Technology, Inc., Long Beach, Calif., Oct. 16-23.

Space Fair, sponsored by the U.S. Navy, Pacific Missile Range Headquarters, Point Mugu, Calif., Oct. 17-18.

Fall Meeting of the Metallurgical Society of the AIME, Sheraton Hotel, Philadelphia, Oct. 18-22.

Symposium on Unconventional Inertial Sensors, sponsored by the Navy, Republic Aviation Corp., and other government agencies, Long Island Graduate Center of the Polytechnic Institute of Brooklyn, Farmingdale, N.Y., Oct. 19-20.

Annual Meeting of the Human Factors Society, Mayflower Hotel, Washington, D.C., Oct. 19-21.

National Electronics Conference, sponsored by the IEEE, McCormick Place, Chicago, Oct. 19-21.

Engineering Aspects of Space Medicine, a short course given by The George Washington University, Washington, D.C., Oct. 19-30.

Eleventh Annual Air Force Science & Engineering Symposium, sponsored by the Air Force Systems Command and the Office of Aerospace Research, Aerospace Medical Division, Brooks AFB, Tex., Oct. 20-22.

East Coast Conference on Aerospace and Navigational Electronics, sponsored by the IEEE, Baltimore, Oct. 21-23.

11th Symposium on Nuclear Science, sponsored by the IEEE and Air Force Office of Scientific Research, Philadelphia, Oct. 27-29.

Annual Meeting and Exposition of the Society of Experimental Stress Analysis, Hotel Manger, Cleveland, Oct. 28-30.

Electron Devices Meeting, sponsored by the IEEE, Sheraton-Park Hotel, Washington, D.C., Oct. 29-30.

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A Bit of a Squashy Subject

ONCE AGAIN, Secretary of Defense Robert McNamara has made it quite plain that his attitude toward the defense industry is sour and that his understanding of the people with whom he works is nil.

The latest promulgation of Dept. of Defense regulations governing acceptance of "any favor, gratuity or entertainment" from contractors by DOD personnel leaves no doubt of that. It contributes nothing to ethical standards of conduct and must surely stand as one of the most insulting documents to both the industry and the military ever to be issued from the Pentagon.

Assistant Secretary of Defense for Manpower Normal S. Paul, in discussing the new code of conduct, describes it as "a bit of a squashy subject." You can bet your boots on that. It is the most squashy, muddle-headed approach to the important question of industry-government ethics we have yet seen.

We believe this magazine has a long record of insisting on proper standards of conduct by the industry in its business dealings with the government. We have editorialized against the "booze, blondes and bashes" invasion of that relationship. We have questioned the propriety of contractors' hiring former military officers purely for their Pentagon influence. We have insisted that the industry must avoid the appearance of evil as carefully as it does evil itself.

We believe that the DOD directive on standards of conduct issued in December, 1961, was a proper approach to the problem. That directive, you may recall, stated that individuals in the Defense Dept. would be expected to exercise discretion where acceptance of a favor "might reasonably be interpreted" as affecting their objectivity in performance of duty.

That directive set the standards of conduct and placed the responsibility for ethical behavior where it correctly belongs—on the individual concerned.

The latest amendment attempts to spell out to the last detail what constitutes ethical performance for the individual. This is an overambitious and misguided effort to achieve the impossible.

The implication that a free lunch, tie-clasp or a drink in a hospitality suite is sufficient to corrupt a military officer or DOD civilian into favoritism is ridiculous, as well as insulting. It calls for abrogation of friendships, denial of conventional methods of doing business and breaches of long-standing trust, all in the name of cleaning up a relationship which Mr. McNamara has regarded with suspicion ever since he took office.

Certainly, one must be on guard against scandal. But there is a world of difference between that and the prim, old-maidish attitude which sees in every warm handshake an illicit relationship. That is the route of the censor and the bluenose. That is the route of the new DOD standards of conduct.

If acceptance of one luncheon from a friend or business acquaintance does not corrupt, what then is the number of lunches, tie-clasps or drinks which does? That question, of course, is impossible to answer in any quantitative sense. Zero is no more of an answer than 100. Ethics is not a question of numbers.

There are officers in the Pentagon who have never accepted a single tie-clasp who are taking cash kickbacks from contractors. They, of course, cannot be expected to report this in writing within 48 hours to the designated representative of their service. But the poor chap who has inadvertently eaten someone's free lunch—perhaps under the mistaken impression a trade association was paying for it—must do so.

We are reminded of Jean Kerr's recital of difficulties with her little boy Christopher, in regard to his conduct when he got up ahead of the rest of the family on Sunday mornings. He was given a series of specific directives: "Don't wake the baby," "Don't go outside in your pajamas," "Don't eat cookies before breakfast," and so on. Unfortunately, she forgot to tell him, "Don't make flour paste and glue together all the pages of the magazine of the Sunday *Times*."

WE BELIEVE the moral for DOD should be apparent. Proper standards can and should be set. But any attempt at detailed regulation of behavior is bound to reduce itself to the world of childishness.

Does this mean that a military inspection team visiting a plant cannot have lunch in the company cafeteria? Does this mean that a company public relations officer cannot invite a visiting military astronaut to have lunch with members of the local press at which he picks up the check? Does it mean that a military officer in the Pentagon who accepts a ride to Washington in the car of the contract representative who has been visiting him must report it within 48 hours? Can a general still in the service have dinner at the home of his former West Point roommate, who happens to be working in the defense industry after retirement?

Presumably, it is not improper under the new rules to attend a banquet sponsored by 27 companies grouped in a trade association. Obviously, it is improper to attend a banquet sponsored by one company. Is two all right? Four? At what number does corruption cease and benefit to government begin?

Is it permissible at a convention to attend a cocktail party paid for by nine companies, but wrong to visit hospitality suites sponsored by the same nine companies? What is it that turns Scotch-and-soda into Scotch-and-corruption?

Mr. Paul emphasizes that the new rules are not the result of misconduct on the part of either DOD personnel or contractors. There was, he says, "no specific instance which brought this thing about."

Even if there were, the original directive was adequate to provide the remedy. But without even a single instance as justification, the whole change appears doubly asinine.

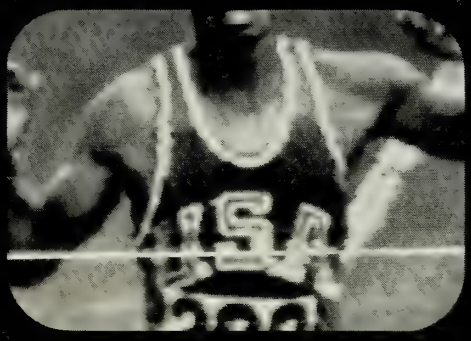
Certainly, there are corrupt officers in the Pentagon and corrupt members of the industry. But we can assure you, Mr. McNamara and Mr. Paul, that nothing exists any more contemptible than your own attitude toward the industry and the people who work for you.

William J. Coughlin

"WE SWITCH YOU NOW TO TOKYO, VIA SYNCOM III"

TOKYO 1964

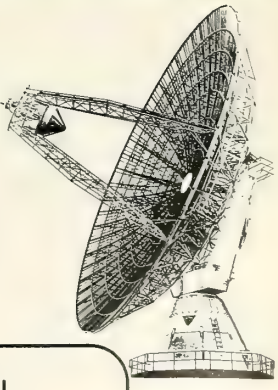




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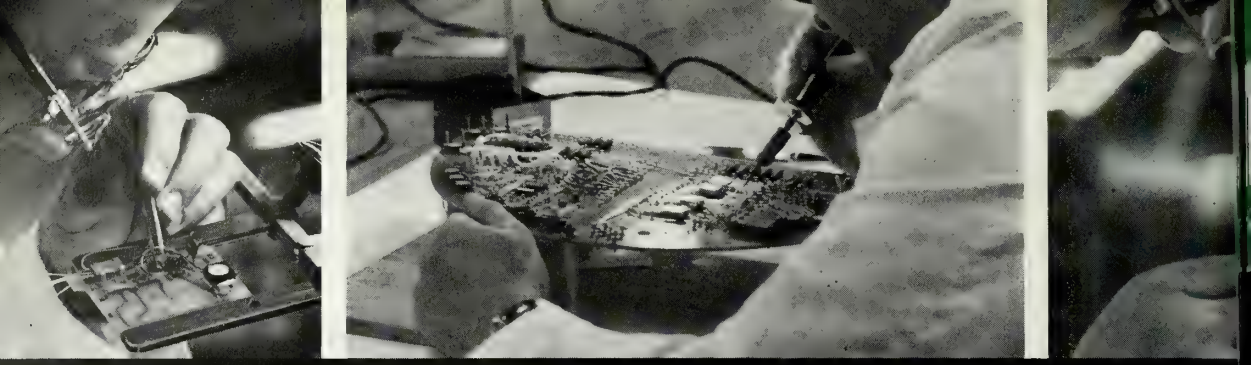


* **SYNCOM III GROUND RECEIVER**
built by Hughes Aircraft Co., operates with Varian's highly stable VA-240 parametric amplifier pump tube.

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OCTOBER 19, 1964

missiles and rockets

THE WEEKLY OF SPACE SYSTEMS ENGINEERING

OCT 1964
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NASA Plans No 'Crash Program' Despite Voskhod

ESRO To Buy U.S. Equipment

IBM's Thin-film Computer

AIAA Report on Entry Problems

'Grating Lobe' Antenna At Martin-Orlando



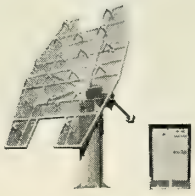
Coming ■ the one-for-all space guidance system. In the past, each new space mission has meant development of a new guidance system, requiring precious time and large expenditures. ☐ Now, to provide maximum reliability and performance at the least cost, Sperry is studying development, under government sponsorship, of a single "core" universal space guidance system, with optional "building block" add-ons for a wide span of missions in a wide variety of space vehicles. This new design will offer accuracy and reliability, with system flexibility. The in-depth experience for this new concept—inertial guidance and control, infra-red optics, digital and analog techniques, radar, displays and system management—is all "under one roof" at Sperry. **INERTIAL DIVISION, Sperry Gyroscope Co., Great Neck, New York.**

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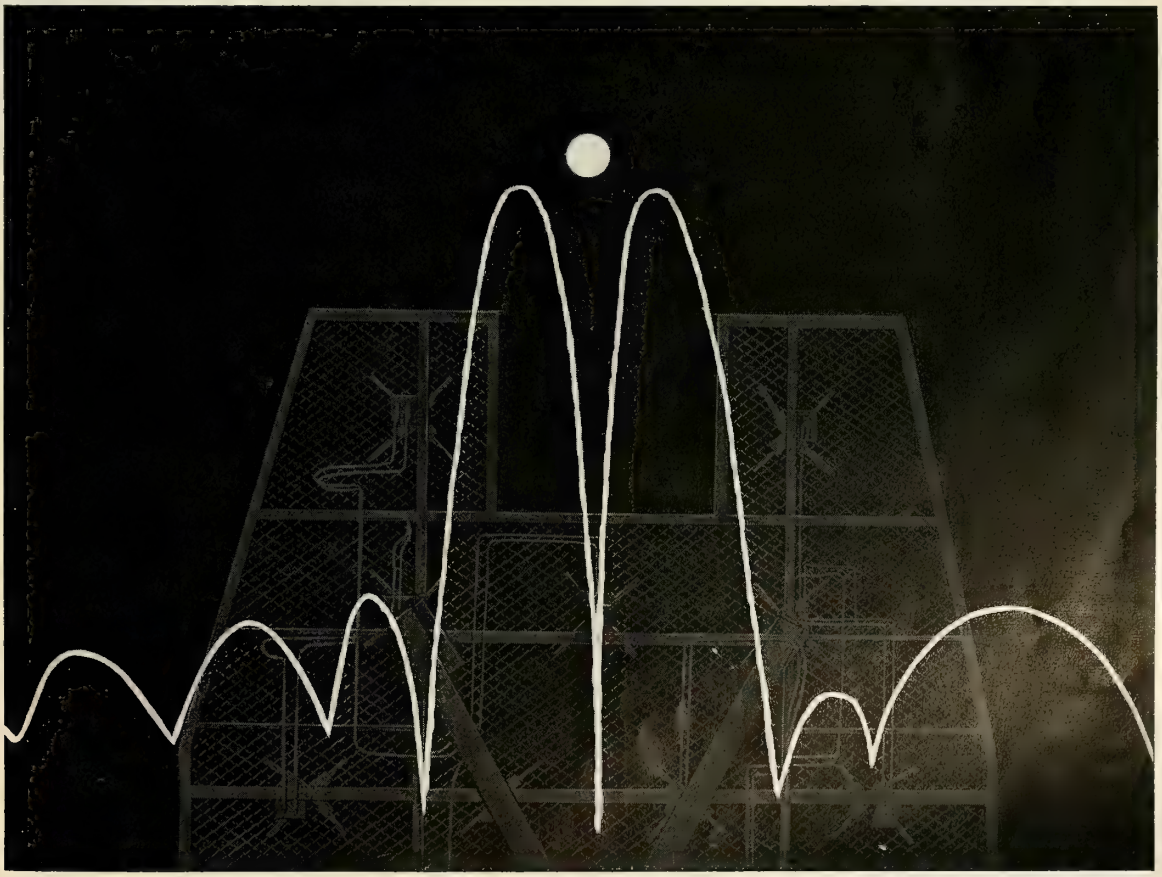
FAN BEAM
TRACKING SYSTEM
canoga

Constantly updating and improving its advanced tracking systems, Canoga has now created a new TELAR antenna array for the Canoga TELTRAC® telemetry tracking system. The result is TELTRAC II, a system which minimizes multipath at low elevation angles. The new fan beam array used in TELTRAC II has an elevation beam width of only 13 degrees at 260 mc. Lower frequencies have slightly wider beam widths. The difference pattern side lobes are below the peak of the sum channel pattern by 21 db. Overall tracking system performance is substantially improved. TELTRAC I with its octagonal crossed dipole array, and now TELTRAC II with the Fan Beam antenna shown here, are being produced in the 200 mc and 400 mc ranges and will be utilized for the follow-on MERCURY and GEMINI programs. These systems can be modified to meet other customer specified frequency ranges.

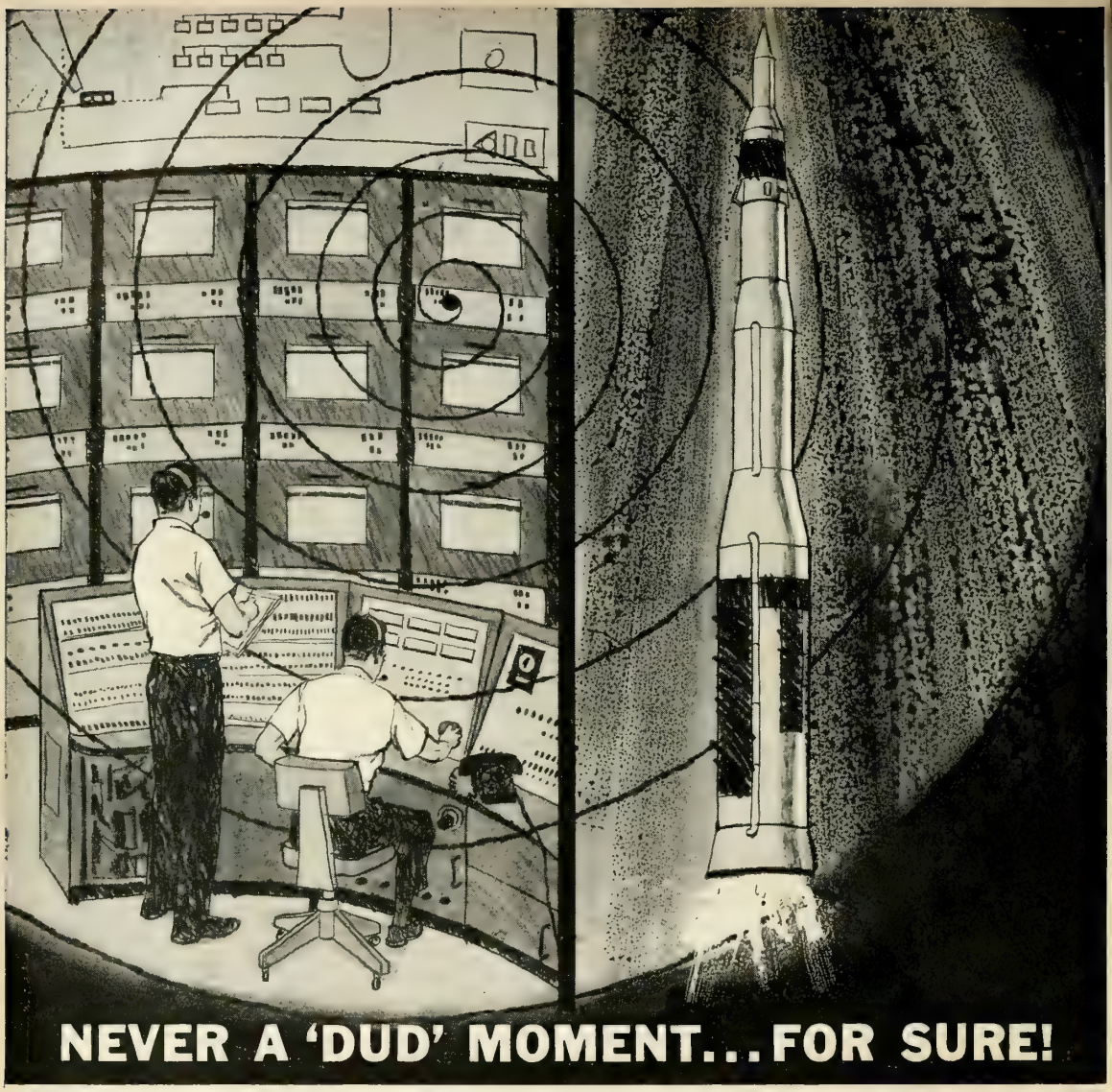


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missiles and rockets

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Volume 15, Number 16 October 19, 1964

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Published each Monday with the exception of the last Monday in December by American Aviation Publications, Inc., 1001 Vermont Ave., N.W., Washington, D.C. 20005. Cable Address: AMERAV.

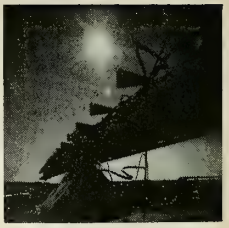
Printed at Judd & Detweiler, Inc., Washington, D.C. Second class postage paid at Washington, D.C.

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Subscription rates: U.S. and Possessions, Canada, and Pan American Postal Union Nations: 1 year, $5.00, 2 years $8.00, 3 years $10.00. All other foreign: 1 year $15.00, 2 years $25.00, 3 years $35.00. Air freight to Europe: 1 year $20.00, 2 years $30.00, 3 years $40.00. Single copy prices: regular issues 50 cents each; special issues $1.00 each. Subscriptions are solicited only from persons with identifiable commercial or professional interests in the missile/space industry. Subscription orders and changes of address should be referred to Circulation Fulfillment Mgr., Missiles and Rockets, 1001 Vermont Ave., N.W., Washington, D.C. 20005. Allow 4 weeks for change to become effective and enclose recent address label if possible.

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THE COVER



Experimental "grating lobe" phased-array antenna mounted at Martin-Orlando research laboratory. Technique has been refined to provide thinned-array design suitable for high-resolution radar that can be carried in supersonic aircraft. See story, p. 43.

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47,700 copies this issue



Saturn . . . the dependable booster of the space age

On January 29, NASA's Saturn SA-5 lifted off from the pad at the John F. Kennedy Space Center carrying the first live S-IV second stage and the heaviest payload ever orbited—more than 37,000 pounds.

It thus established beyond a doubt the dependability of Saturn I, and its fitness for the key role it will play in our nation's space exploration program.

The role of the upcoming Saturn IB in the NASA Apollo program will be to earth orbit manned Apollo spacecraft vehicles for tests of the rendezvous and docking methods to be used in later manned lunar landing flights.

It is also the logical vehicle for all programs where relief from the present weight and space restrictions on payload are desired.

In fulfilling its role in the expanding national space program CHRYSLER Corporation SPACE Division—prime contractor to NASA for the first stage of the Saturn I and IB vehicles—has a continuing need for creative, experienced engineers and scientists at all levels and in many disciplines. Some of the challenging positions now open are listed on the page opposite.

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letters

Lunar Dust Solution

To the Editor:

In regard to letters to the editor published in MISSILES AND ROCKETS' Aug. 31 and Sept. 28 issues, this is intended as a suggestive question.

With all of the debate over whether there is dust on the lunar surface, how thick it is—if it is there, what its consistency is, etc., it is logical to me that with our present capability the issue could be simply solved.

An already proven capable engine (I presume we have some) could be made available with schedule alterations, equipped with a small stage booster ahead of the camera stage. At a triggered time before impact on the lunar surface (it would) separate from the camera stage, boost itself ahead of the camera (at the same time slowing the camera stage down) and go into the surface.

With the camera following behind relaying photos home, we could prove beyond doubt what is there and what it is like and get on with our work in less time.

Who knows, someone may be smart enough to save some bucks with an early answer.

B. G. Moss
Seattle

Gemini RCS Propellants

To the Editor:

Ref: "GT-2 Arrives at Cape" (M/R, Sept. 28, p. 15).

Upon reading the paragraph beneath the photograph, specific attention was taken to the sentence, "The 7,000-lb. spacecraft will next proceed to the Fluid Test Complex, where its hydrogen peroxide thrusters will be test-fired."

Back in the glorious days of the *Mercury* program, the fluid used in the reaction control system (RCS) for spacecraft maneuvering was hydrogen peroxide.

The *Gemini* spacecraft RCS utilizes monomethyl hydrazine and nitrogen tetroxide as the fuel and oxidizer respectively; these will be the propellants for all flights, beginning with *GT-2*.

It is hoped that you will make this correction in the next M/R for your readers.

Roderick S. Bass
Launch and Flight Operations Engineer
Manned Spacecraft Center
NASA
Houston

'How to Play Unpolitics'

To the Editor:

I read with great interest your Oct. 5 editorial ("How to Play Unpolitics").

Really, what did you expect from a party hack with makings of a political commissar?

A. J. Jankunas
Cicero, Ill.

Space Facts for Youngsters

To the Editor:

Recently I obtained from an ROTC officer at the University of Portland your address, from which I hope to obtain material on space, missiles and the like for my young son.

Bill is only 15 but has an insatiable yearning to learn more about space. Most schools do not offer any such material in their course of study and I feel he should have it to satisfy his desires as he plans to follow this line in his education in the next few years, especially college.

Is it possible to be on a mailing list for such publications?

Mrs. William Fleming, Jr.
LaCenter, Wash.

The National Aeronautics and Space Administration maintains an office which supplies such material for students. Requests from Mrs. Fleming and other readers with similar interest should be addressed to:

Educational Publications
Code AFEE-5
NASA
Washington, D.C. 20546
—Ed.

Cards Si, Tokyo No

To the Editor:

I hope that the television schedulers in the future will do a better job of bringing us the blessings of worldwide TV than was provided from the Olympics. Give me (at this writing) the live World Series show.

Cass Scherman
St. Louis

To the Editor:

As a taxpayer who contributed his tiny bit to the cost of the program, I protest the muzzling of *Syncom*.

Frederick Levine
New York

Reprints of ASW Report

REPRINTS of the entire Special Report on Anti-Submarine Warfare published in the September 21 MISSILES AND ROCKETS *may be obtained from:*

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Excellent positions in other disciplines are also available in Huntsville and Cape Kennedy, as well as in New Orleans.

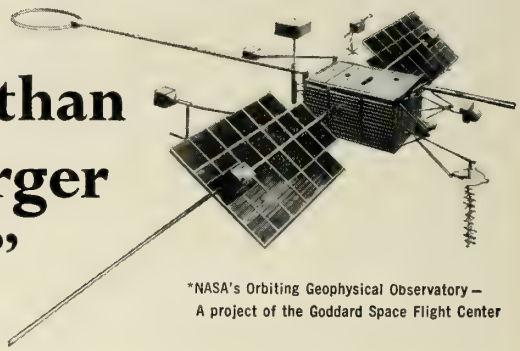
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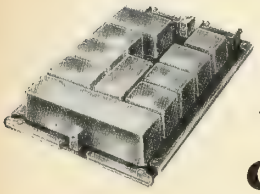
NASA said:

"Develop for 'OGO'* an 8-channel digital data processor consuming no more than 700 mW and no larger than 16 cubic inches."



*NASA's Orbiting Geophysical Observatory – A project of the Goddard Space Flight Center

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The Countdown

WASHINGTON

ASTOR To Be Competitively Procured

BuWeps apparently plans to solicit proposals for its next production buy of the *ASTOR* (nuclear *Anti-Submarine Torpedo).* Westinghouse developed the weapon and has been producing it on a sole-source basis until now. This action, if taken, would seem to confirm a new policy on the part of the Navy. Recently, the service has competitively procured *Bullpup,* the *AQM-37A* and the *Sidewinder IC* guidance and control.

Cheap SAM Missile Sought by Navy

An "austere" surface-to-air missile system for deployment on amphibious and auxiliary vessels is being considered for development by the Navy. BuWeps is looking for a contractor to develop a prototype shipboard system from Government-furnished missile, launcher and fire control equipment.

Apollo Experiment Needs Updated

NASA has issued a new booklet detailing the types of experiments it would like to launch on manned *Apollo* Earth-orbital and lunar missions. The *Apollo* In-flight Experiment Guide, dated Sept. 15, brings up to date an earlier guide published on June 11. About 80 lbs. of the *Apollo* Command Module will be available for experiments and another 500 lbs. of inaccessible experiments can be accommodated in the forward skirt of the S-IVB stage.

New Penetration Aid Being Tested

Infrared flares ejected from a nose cone during re-entry are a promising new penetration aid under test in the *ABRES* program. The flares would extend the range of confusion devices into another part of the electromagnetic spectrum. And, since infrared is an important discrimination device in the atmosphere, IR flares giving approximately the same signature as the warhead could defeat atmospheric filtering of decoys until it was too late to react with a defensive missile.

START Delayed Until Next Year

A Defense official has told COUNTDOWN that the START program package is unlikely to be completed before the end of the year. Thus, the program which is to include 10-14 different tasks in the area of maneuverable re-entry technology will be more than a year in the making. This program was to fill the gap left last December when Secretary of Defense McNamara cancelled the *X-20.*

Air-Breathing Boosters Coming

Both the Dept. of Defense and the Air Force feel that the next improvement in first-stage propulsion units will come from air-breathing boosters. AFSC commander Gen. Bernard A. Schriever told COUNTDOWN air-breathing propulsion, perhaps in conjunction with new advances in materials, could be an area for considerable R&D expansion.

JPL Fights Bugs in Mars Mariner

Reason for removal of ultraviolet photometer from Mars *Mariner:* device caused arcing that obliterated all television data in a systems test, and JPL had no time to do anything about it. UV photometer was to have provided information about Martian atmosphere. Other problems met in a 10-day systems test in a simulator included difficulty in getting the narrow-angle planet tracker to acquire Mars, and failure of both transmitter power amplifiers to operate.

INDUSTRY

AUSA Refunding Convention Monies

As a result of Dept. of the Army implementation of the Standards of Conduct directive immediately, rather than waiting until the Nov. 24 effective date, the Association of the United States Army is offering refunds to companies that reserved tables for its annual convention Nov. 16-18. Hospitality suites will be replaced by an AUSA-operated courtesy lounge available to convention attendees and industry representatives. The latter will have to pay a fee for use of the lounge.

Two Companies Vie for STARS

Goddard Space Flight Center has selected Beckman Instruments, Inc. and Electro-Mechanical Research, Inc. for negotiations leading to award of a contract for three Satellite Telemetry Automatic Reduction Systems (STARS). Winning firm will receive a contract expected to be valued at about $2.5 million.

Westinghouse Apollo Camera Award Near

Westinghouse Electric Corp.'s Aerospace Div. is expected to receive a contract before the end of the month for a hand-held television camera for *Apollo* astronauts. At least 12 items, including prototypes and flight models, will be produced under the contract, expected to be worth $2.2 million.

Douglas Proposes Extra Saturn V Potential

Douglas Aircraft Co.'s Missile and Space Systems Div. says the escape potential of the *Saturn V* vehicle can be hiked by nearly 10,000 lbs. through three modifications in the S-IVB stage. The changes would include substitution of high-performance insulation for the internal hydrogen tank insulation, substitution of a cryogenic attitude control system for the storable propellant modules, and programming engine mixture ratio to obtain higher specific impulse late in flight.

Boeing Awards Lunar Orbiter Subcontract

Boeing has given Radiation Inc. of Melbourne, Fla., a subcontract of about $875,000 for pulse-code-modulated multiplexer encoders to be used aboard NASA's *Lunar Orbiter* spacecraft. The devices will transmit guidance and control data before and after the 800-lb. satellites go into orbit around the Moon. At the same time, Boeing awarded Electronic Communications, Inc., of St. Petersburg, a $250,000 contract for radio equipment to be used in the *Minuteman* improvement program.

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IN THE AIR OR OUTER SPACE... DOUGLAS GETS THINGS DONE!

The Missile/Space Week

More Beacon Explorers Soon

NASA officials expect to launch the third satellite in the *Beacon Explorer* program in three to six months.

The exact launch date will be determined after data from the successful *Beacon B* satellite which was placed into orbit on Oct. 9 by a *Scout* launch vehicle. The satellite is now known as *Explorer XXII*.

The launch from Vandenberg AFB, Calif., put the satellite into an orbit with an apogee of 669 mi., perigee of 549 mi. and a period of 104.7 minutes.

The third satellite, *Beacon Explorer C*, will be launched from Wallops Island into an orbit of about 620 mi.

All frequencies of the satellite have transmitted data, and information on the vertical profile of the atmosphere is being received.

An attempted laser experiment on Oct. 11 had inconclusive results. Photos were made during two passes of the satellite, but the return beam is apparently too weak to differentiate between radio noise and light from stars.

NASA scientists are still hopeful and further laser tests are planned. They said some definite idea of the success of the experiment is expected in about a week.

The advantage of the laser tracking method is that it offers a potential accuracy to within 10 meters in range and 3-4 seconds of arc in angular measurement.

Deep Sea Meeting Set

Industry will receive the initial plans for the Navy's Deep Submergence Systems Project at a conference Nov. 24.

According to Vice Adm. William A. Schoech, chief of Naval Material, about 450 potential contractors have been invited to the Washington, D.C., meeting.

The scheduled briefings will bring potential contractors up to date on the proposed development program, which is being managed by the Special Projects Office of the Office of Naval Material. A review group has called for a five-year program to give the Navy rescue search and recovery capabilities in ocean depths down to 20,000 ft.

Conference participants will include Rear Adm. I. J. Galantin, ONM director, Dr. John Craven, chief scientist, Capt. J. H. Dolan, head of the Deep Submergence Systems, and Capt. George Bond, USN Medical Corps., who will direct the man-in-sea part of the program.

Saturn Complex Bids Opened

The Cleveland construction firm of McDowell-Wellman was the apparent low bidder at $3,533,333 Oct. 14 when NASA opened bids on the modification of the service tower of *Saturn* Launch Complex 34 at Cape Kennedy.

The 310-ft. tower is being altered to accommodate *Saturn IB*. Sixty tons of steel reinforcement will be added to the structure, and a 24,000-sq.-ft. protective weather screen will be constructed alongside.

The job, which will also include construction of eight framed and decked service platforms and the modification of four existing elevators to provide more landings, is expected to be completed in eight months.

Major Design Changes Seen

A predicted trend toward increased human control in future manned space missions would have a profound effect on spacecraft subsystem and component design, industrial researchers have concluded.

Extended in-flight maintenance by astronauts could also mean a revolutionary change in launch pad design, a Martin Co. spokesman told a meeting of the Society of Automotive Engineers. William O. Campbell outlined a picture in which onboard checkout, countdown and emergency repair during extended manned missions would result in responsibility for checkout centered within the spacecraft. This would lead to simpler launch pad design, he said.

Shots of the Week

The Soviet Union on Oct. 12 confirmed months-old rumors of an impending space spectacular when it launched three men aboard the same spacecraft (see story, p. 13). The craft, called the *Voskhod* (Sunrise), was safely returned to Earth 24 hrs. and 17 min. after launch after 16 orbits.

- NASA launched an *Argo-D4* and four *Nike Apache* rockets from Wallops Island, Va., during a 12-hr. period Oct. 7 and 8 in a series of upper atmosphere measurements. The measurements made were: wind direction and velocity; intensity of Earth's magnetic field; temperature and density of electrons; composition and density of ions above 150 mi.; and ion current systems.
- NASA launched *Beacon Explorer B* from Wallops Island, Va., Oct. 9. (see item this page).
- The Navy launched a *Polaris A-3* missile from the nuclear submarine, USS James Madison, off the Florida coast Oct. 13. The successful firing brought the *A-3's* record to 15 successes in 16 shots and completed the current test series.
- The Soviet Union launched *Cosmos 48* Oct. 14, just eight days after the orbiting of *Cosmos 47* and 2 days after the *Voskhod* three-man spacecraft.

'Building Block' Approach Cited

The "building block" approach to space technology has been successfully demonstrated by the Air Force satellite inspector program, according to Dr. Brockway McMillan, Undersecretary of the Air Force.

Within a year after a Dept. of Defense directive to establish a capability, "we had an operational system in space which has achieved a demonstrated capability by tests against selected U.S. satellite targets," McMillan told the national meeting of the Society of Automotive Engineers in Los Angeles.

In addition, DOD has successfully accomplished the *Vela* nuclear detection satellite program and the intermediate DOD comsat program is now moving toward a definitive hardware contract, McMillan said.

Stressing that there is no objective for creation of a space system for its own sake, he said that systems can be expected to evolve from a basis of sound technology and recognized needs.

The AF *Manned Orbiting Laboratory (MOL)* program can be expected to determine future space programs for both the Air Force and DOD, McMillan said, "because we intend to realistically determine man's utility in performing military functions in space." The experimental program will also provide knowledge of DOD command and control networks and overall mission performance of military type hardware and operations, McMillan said.



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No 'crash program' planned . . .

Voskhod Shows Big Soviet Lead

But Administration officials say U.S. can still catch up; they doubt that new booster was used, though it may be in works

by Hal Taylor

THERE WILL BE no significant increase in NASA's Fiscal Year 1966 budget request despite the Soviet Union's most recent space spectacular—the successful orbital flight of three cosmonauts in a *Voskhod* spacecraft weighing about 15,000 lbs.

The spacecraft—a modified *Vostok* vehicle that was secretly man-rated in the Soviet's *Cosmos* spaceflight series—was termed "an important achievement, but no basis for a crash U.S. program," by Dr. Edward C. Welsh, acting chairman of the National Aeronautics and Space Council.

The Johnson Administration statement was made even though the Russians' 24-hour and 17-minute flight put this country at least two years behind in the space race. A similar U.S. flight will not be made until late 1966 at the earliest.

Hesitancy to sharply increase the space agency budget is based in part on a study made of a so-called "crash program." NASA learned that such a program would cost several hundreds of millions of dollars and would gain at best only six to 12 months.

It is also partially based on the belief of U.S. officials that the *Voskhod* and its launch vehicle—even though the Soviet Union claimed both were new and powerful vehicles—still are not capable of achieving a manned lunar landing.

● **First of a series**—Details of the Soviet program were revealed by U.S. officials following the 16-orbit-plus flight of the manned *Voskhod* spacecraft launched on Oct. 12. Aboard were the pilot, Col. Vladimir Komarov, scientist/engineer Konstantine Feoktistov and the physician, Dr. Boris Yegorov.

The launch took place at 3:30 am EDT Oct. 12. The trio returned safely to Earth at 3:47 am EDT Oct. 13, 1964. Unlike previous cosmonauts, they stayed in their capsule and did not parachute to Earth.

Soviet scientists and government officials hailed the flight as the start of a series of manned spaceflights leading to an orbital space platform and flights to the Moon and planets.

The objective, they said, was to test out the new craft, examine multi-man crews in action, study scientific and human factors in flight, and carry out medical biological research in the conditions of long-duration flight.

While U.S. officials had been expecting a new manned Russian space attempt, the *Voskhod* flight plan was a partial surprise. Previously, U.S. speculation had centered around either a two-man orbital attempt or a possible orbital rendezvous mission.

● **Tipoff**—There was no mention—at least publicly—of a three-man flight, which is surprising in itself because U.S. officials have been aware of *Voskhod's* existence for some time.

It was first revealed by NASA Administrator James E. Webb in testimony before the Senate Space Committee on March 4, 1964.

"I would say that the Russians have proceeded in a quite orderly way to develop and exploit both in a manned and unmanned fashion a large 10,000-lb. spacecraft (*Vostok*) which they have shown a capacity to recover," Webb said.

"They have done a good deal of experimental work with the use of a spacecraft of something like 15,000 lbs., which they are developing apparently to place in Earth orbit and then eject from orbit for purposes that are not clearly known to us at this time, although the pattern of flights clearly indicates an interest in deeper penetration into space beyond the Moon." Webb told the Committee.

● **Man-rating**—Officials have also been aware that the Russians have been man-rating the vehicle in the so-called *Cosmos* satellite series.

The most recent R&D flight was on Oct. 6, 1964, when the Soviet Union announced the launching of *Cosmos 47*. The spacecraft, Moscow Radio reported, was orbiting the Earth every 90 minutes with an apogee of 413 km and a perigee of 117 km. After a flight of one day,

(Continued on page 14)

Plane Changes Planned for GT-3

ASTRONAUTS Virgil Grissom and John Young will perform three plane changes and a maneuver called a "radial burn" during the first manned *Gemini* mission in early 1965 (*GT-3*).

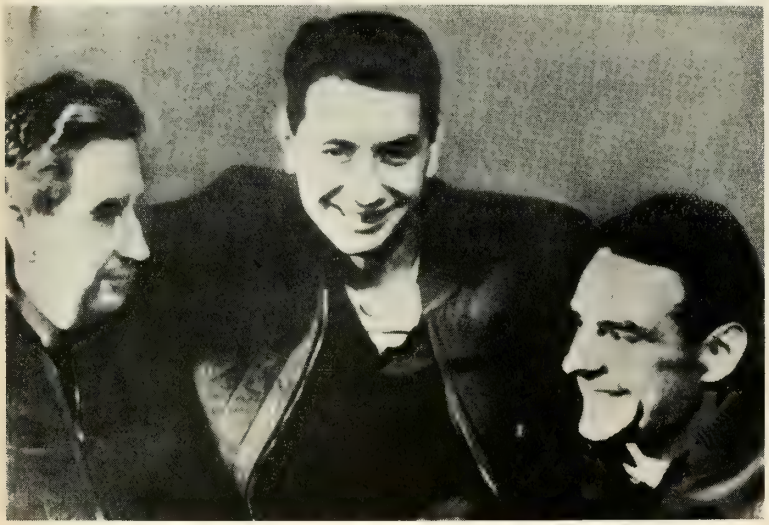
"In-and-out" plane changes will be made over the Indian Ocean during the second orbit. The spacecraft will leave and re-enter the orbital plane established during its launch. The angle change will be "negligible" and the maneuvers will "cancel out."

A third plane change will be performed at the end of the second orbit over the west coast of the United States. This angle change will be "in the hundredths of a degree," but will affect the splashdown point in the Atlantic.

The *Gemini* is capable of making a total plane change of one-half degree, offsetting its track across the ground as much as 30 mi.

The "radial burn" will translate the spacecraft away from Earth to rotate the line of apsides (major axis). This will not change the shape of the orbit, but will relocate apogee and perigee. The maneuver will occur over the west coast of Mexico at the end of the first orbit.





ABOVE: Col. Vladimir Komarov, pilot (left), and Konstantine Feoktistov, scientist, as they appeared to Soviet televiewers while orbiting in their Voskhod spacecraft. Below: The third member of the capsule's crew, Dr. Boris Yegorov, a physician, appears in center of photo, taken after completion of the 16-orbit mission. Feoktistov is at left and Komarov at right.

it was ejected out of orbit on Oct. 7.

Voskhod's orbital parameters were almost exactly the same. It had an orbital period of 90.1 minutes with an apogee of 255.6 miles and a perigee of 112.5 miles. It orbited the Earth for exactly 24 hours and 17 minutes. Four other *Cosmos* satellites had similar orbital periods with only slightly different high and low altitudes.

● **Gap assessed**—Officials admitted the long lead of the Soviets in manned spaceflight, but declared this nation could still catch up because *Voskhod*—by itself—is not capable of a flight to the Moon.

While the new craft weighs 3,000 lbs. more than the *Apollo* spacecraft's Command Module, it is certain that a vehicle weighing many thousands of pounds more would be required to carry the necessary propulsion and power requirements of a lunar mission.

This could be provided by a series of rendezvous in Earth orbit. This is the mission mode which the Russians have apparently decided is the best way of going to the Moon and U.S. officials foresee such rendezvous flights in the next year or two.

It is also expected that sometime next year—just about the time that this nation will be launching two astronauts on a three-day flight in the *Gemini* spacecraft—the Russians will be sending their three-man cosmonaut teams on orbital missions lasting from one to two weeks.

● **New booster coming?**—The U.S. officials also discredited Soviet claims that the *Voskhod* launch vehicle was a new booster more powerful than this country's *Saturn I*. They believe that it is the same booster used in the earlier *Vostok* manned flights with perhaps uprated upper stages or a new third stage.

They admitted, however, that there is "increasing evidence" that the Soviet Union is developing a powerful new booster, perhaps in the same class as the space agency's 7.5-million-lb.-thrust *Saturn V*. They refused to state the basis for their belief, apparently for national security reasons.

The U.S. space experts also discounted reports that the Soviet flight may have been aborted after one day because of communications or other technical problems. Instead they see the flight as the first step in a long series of flights which will build up in duration. They pointed out that the first *Vostok* flight lasted only one orbit, but then was followed by a one-day flight.

● **Life support**—*Voskhod* marked the first flight in which the cosmonauts discarded their space suits in favor of a "shirt sleeve" atmosphere. Space medicine experts say that this may only indicate their confidence in their existing system—the one already used in the *Vostok* flights.

This system, which is a mixture of oxygen and nitrogen at about a 20/80 ratio at 14.7 psi (sea level) conditions, has been described in Soviet literature as being supplied by potassium superoxide, with high-pressure oxygen as a backup source for emergency and critical mode use. The Soviets claimed some time ago that this system was designed for an operation from 10-12 days. This would be sufficient for a flight to and from the Moon.

The flight climaxed months of unmanned Soviet space activity which saw 22 *Cosmos* satellite launches and four *Elektron* probes.

● **Political reaction**—Sen. Barry Goldwater, Republican candidate for the Presidency, called the flight "shocking news" and demanded a "major redirection of U.S. space efforts."

"Near space, the area in which the orbital flight takes place, is the key to the military use of space. The nation that commands near space could, after developing proper weapons and maneuverable spacecraft, dominate the Earth.

"I have pleaded for years for a realistic emphasis on research in this area. Instead, this Administration has dedicated billions of dollars and the virtual entirety of its space efforts to a Moon shot." ■

July success conclusive . . .

NASA Announces No Further SERT Flights Are Necessary

THE SPACE AGENCY has announced that it has dropped plans for a second flight of its *SERT (Space Electric Rocket Test)* because of the success of *SERT I.*

It said that the July 20 flight fulfilled the prime objective of proving that a stream of ions can be neutralized in space. It also demonstrated that the ion stream could produce thrust. Since the flight, scientists have continued ion engine research on the ground.

Ion engines have the advantage of low propellant consumption and long operation, although the thrust is extremely low. These are great advantages in propulsion for future deep space missions, where little thrust is needed.

● **Conclusive shot**—The *SERT I* flight from Wallops Island, Va., considered a significant first in the electric thrust program, ended speculation about neutralization. Before the shot, it had not been proved conclusively that an ion beam could be neutralized effectively. Without neutralization, there could be no fast-moving stream of particles to provide thrust.

SERT I was launched by a *Scout* rocket on a ballistic path to a height of 2,550 mi. over the Atlantic for a distance of 2,100 mi. During the 47-min. flight, the spacecraft was a test bed for two ion thrustors, mounted at right angles to the axis of the booster's fourth stage. In operation, one engine would increase the spin of the stage and the other would reduce its rpm rate.

The information gathered has been studied by scientists at Lewis Research Center, who conducted the experiment for NASA's Office of Advanced Research and Technology.

● **Engine performance**—*SERT I* carried two engines—a Hughes Research Laboratories contact-ionization engine using cesium propellant and an electron-bombardment engine using mercury propellant and made by NASA's Lewis Research Center.

The Hughes engine failed to operate after repeated tries. The Lewis engine produced an ion beam that developed 0.0055 lbs. thrust. An increase in the spin rate of the spacecraft was detected by an accelerometer.

The Lewis engine operated for 19 min., but experienced automatic shutdowns varying from 2 to 16 seconds. Periodic shutdowns, caused by electrical breakdowns that become less frequent after the engine has been in operation, are normally encountered in vacuum tank tests for several minutes to a few hours following the ignition of an ion engine.

Additional confirmation of the neutralized ion beam came from an instrument probe, used to survey the beam seven inches behind the engine. The probe showed that the beam had expanded by the same amount as found in vacuum tank tests. When the neutralizer was turned off, the ion beam stopped. ■

Ten proposals received . . .

Navy Evaluates Underwater Range Plans

MANAGEMENT PROPOSALS from 10 companies are being evaluated by the Navy's Bureau of Weapons as the first step in establishing a new underwater tactical range in the Pacific. To be located off the West coast of Lanai in the Hawaiian Islands, the range will be used to test naval weapons, such as *Subroc, Asroc* and torpedoes, over their full range in a three-dimensional, "near-real-time" environment.

BuWeps initially solicited proposals from 68 companies for the estimated $10-15 million facility, but only 10 companies responded. After evaluation of the "methods and management" proposals, the Navy plans to solicit technical proposals from these companies—probably in January—and to award a firm fixed-price contract for the range by next summer.

The underwater tactical range, according to the Navy, "will be used for fleet tactical training with underwater weapons and for evaluating the performance of various anti-submarine (ASW) weapons by tracking the targets, the launching vehicle and the weapons' entire trajectory." The range will cover an area of approximately 50 sq. mi., with water depth varying from 350 to 900 fathoms.

● **Capabilities sought**—requirements for the range include a continuous monitoring of the oceanographic environment, an underwater acoustic array, an in-air tracking capability and a central command-control center with requisite data-processing equipment into which all these subsystems can be tied.

The acoustic array—consisting of a minimum of 38 hydrophones, each placed 2,880 yds. from the other—must have a tracking accuracy, at a 95% confidence level, of ± 10 yds. and be capable of being placed within 800 ft. of the bottom of the test range. It also must be able to track up to eight units simultaneously with 0.5-2 fixes per sec per unit being tracked and with a 30-knot destroyer interference.

● **Air radar system**—The in-air radar tracking system will consist of the *Nike-Ajax* Mod V radar for automatic infrared, radar (skin and beacon) and manual TV tracking while the *Nike-Ajax* acquisition radar will be used for air surveillance. Both of these items are government-furnished equipment.

In addition to hydrophone and radar data, the data-processing system must be able to accept information from various other sensors, including internal torpedo tapes, theodolite film, sound measurement recordings, strip charts and data collected from sensors aboard ships.

Oceanographic data will be processed on a semi-real time basis, that is, the oceanographic data will be monitored continuously but will be processed only on a non-interference basis with test operations. ■

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Candidates' Records on Defense and Space Bills

WHILE MANY STATEMENTS have been made on defense and space issues during this campaign, the voting records of the top candidates would seem to provide a solid basis for evaluating the promises made.

In the accompanying table, the yeas and nays of the four candidates are recorded on key missile/space issues during the last six years. Failure to vote is denoted by a question mark. The symbols PF and PA represent paired for and paired against, respectively. Not listed are bills in which only voice votes were taken.

While President Lyndon B. Johnson is not represented for the three years from 1961 to 1963 when he served as Vice President, his position as President is indicated on the amendments offered to the Administration's money bills during 1964. His voting record is shown for the years 1959 and 1960.

Experience each candidate has had in Congressional defense and space matters can be inferred from their committee memberships. Johnson's lies in both space and defense, as he was a member of the Senate Armed Services committee and first chairman of the Aeronautical and Space Sciences Committee. He also served as a member of the Appropriations Committee, which handles both areas.

Sen. Goldwater also has been a member of the Armed Services Committee, and served on the Select Small Business and Labor and Public Welfare Committees.

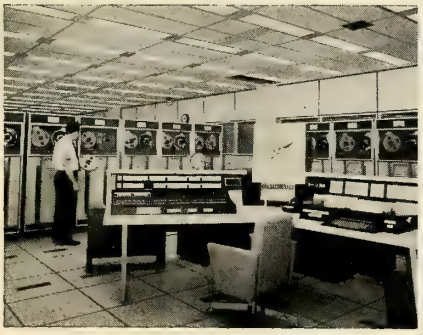
Sen. Hubert H. Humphrey headed a Small Business subcommittee that this year investigated the impact of defense spending. He also has been a member of the Appropriations and Foreign Relations Committees.

Rep. William E. Miller has not been associated with any committees directly dealing with military or space matters, having been a member of the Judiciary and Un-American Activities Committees, and the Republican Congressional Committee. ■

	Johnson	Humphrey	Goldwater	Miller
DOD AUTHORIZATION				
1964—Senate				
—Passage of bill	(yea)	Y	Y	
1964—House				
—Passage of bill				?
1963—Senate				
—Amendment to cut the extra $196 million voted for the Nike-Zeus.		Y	?	
—Amendment to add $134 million for nuclear submarines		N	?	
—Passage of bill.				
1963—House				
—Amendment to add $363 million for two RS-70's.	(nay)			PA
—Amendment to cut DOD bill except AF R&D and Navy procurement, by 5%.	(nay)			PF
—Passage of bill.				?
1962—Senate				
—Passage of bill.		Y	?	
1962—House				
—Passage of bill.				Y
1961—House				
—Passage of bill.				Y
DOD APPROPRIATION				
1964—Senate				
—Amendment to cut appropriations by 4%.	(nay)	N	?	
—Amendment to cut all appropriations 2%.	(nay)	N	?	
—Passage of bill.		Y	?	
1964—House				
—Passage of bill.				?
1963—Senate				
—Amendment to cut all by 10%.		?	N	
—Amendment to cut MMRBM $60 million.		?	N	
—Passage of bill.		?	Y	
1963—House				
—Passage of bill.				Y
1962—Senate				
—Amendment to cut RS-70 $320 million.	(yea)	?	N	
—Passage of bill.		?	Y	
1962—House				
—Passage of bill.				Y
1961—Senate				
—Amendment to cut $525 million extra voted for manned bombers.		N	N	
—Passage of bill.		Y	Y	
1961—House				
—Passage of bill.				Y
1960—Senate				
—Passage of bill.	Y	Y	Y	
1960—House				
—Passage of bill.				Y
1959—Senate				
—Passage of bill.	Y	Y	Y	
1959—House				
—Passage of bill.				Y
NASA AUTHORIZATION				
1964—Senate				
—Amendment to cut $267 million from NASA or 10% Apollo.	(nay)	N	?	
—Passage of bill.		Y	?	
1964—House				
—Passage of bill.				?
1963—Senate				
—Amendment to cut $307 million or back to House level.		N	Y	
1963—House				
—Passage of bill.				?
—Vote to recommit conference bill back to committee and keep at House level.				Y
1962—House				
—Passage of FY '62 sup.				Y
—Passage of bill.				Y
1961—House				
—Pass conference bill.				Y
1960—Senate				
—Passage of bill.	Y	Y	Y	
1960—House				
—Passage of bill.				Y
1959—Senate				
—Passage of bill.	Y	Y	?	
1959—House				
—Passage of bill.				Y
NASA APPROPRIATIONS				
1964—Senate				
—Amendment to cut by $100 million	(nay)	N	?	
1964—House				
—Amendment to cut by $200 million				?
1963—Senate				
—Amendment to cut by $519 million		N	PF	
1963—House				
Amendment to cut by $200 million				Y
—Passage of bill.				?
1962—Senate				
—Amendment to cut NASA $104 million.		?	?	
—Passage of bill.		?	?	
1962—House				
—Passage of bill.				Y
1960—Senate				
—Supplemental funds to NASA	Y	?	?	
1959—Senate				
—Passage of bill.	Y	Y	?	

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Dr. Hall declares . . .

Recoverable Booster Development Must Await Bigger Savings Yields

by James Trainor

CURRENT CONCEPTS for recoverable boosters do not offer "sufficient promise" of real economic gains to justify their development, says Dr. Albert C. Hall, Deputy Director (Space) Defense Research & Engineering.

Hall told the Flight Mechanics and Entry Technology conference at Williamsburg, Va., that "there seems to be little question that our scientific and engineering communities could, for an RDT&E cost of $2 billion, produce a re-entering and re-usable booster system. The ideas that have thus far been explored, however, do not offer sufficient promise of the real economic gain that would be required to justify such a large R&D expenditure."

The Oct. 12-13 meeting was sponsored by the American Institute of Aeronautics and Astronautics. (See related story, p. 41).

In a simplified version of the accounting involved, Hall cited a booster with a payload of 25,000 lbs. *(Titan-III-C* class), which could be developed for approximately $1 billion and be produced in "reasonable numbers" for $14 million.

Assuming the $2 billion for development of a re-usable system and assigning vehicle costs to manufacturing, factory test and launch costs (one-third to each category), the re-usable vehicle might allow savings of two-thirds of the manufacturing cost and one-half of the factory test cost.

"This would mean that the cost per flight of a re-usable vehicle would be about 61% of that of an expendable booster," Hall pointed out. This saves $5.5 million per flight over the $14 million expendable vehicle.

Assuming the launch rate doubles over the next five years from the present 150,000 lbs. in orbit to 300,000—a figure Hall defended on the basis that the weight in orbit has increased only 30% over the last three years—it would take 60 years to amortize the initial R&D investment in the re-usable system.

"It seems unlikely, therefore, that re-usable booster concepts presented will produce the desired economies in space transportation costs," he concluded. "Of course, factors such as a fundamentally new propulsion concepts, or a genuine breakthrough in the reduction of test and launch costs might cause the re-usable booster to be economically attractive."

• **Re-entry technology**—Citing the history of Air Force and Army exploratory development work on IBCM nose cones, Hall drew a parallel between that effort and the current Project Defender and *Advanced Ballistic Re-entry System (ABRES)* programs.

"Today's re-entry body represents . . . considerable improvement over the early efforts to achieve successful re-entry. The advent of ablation shield materials made from the organic polymers; the advent of glass fiber laminates, Teflon and phenolic-zirconium foam all have enhanced our efforts to design re-entry bodies whose shapes and weight permit us to exploit a much greater degree of sophistication in weapon system design."

The *ABRES* program is geared to the development and test of penetration aids as well as studies of re-entry phenomena and the development of new re-entry bodies. Defender, although the converse of *ABRES* in that it seeks to defend against ICBM attacks, is also concerned with missile phenomena during launch, mid-course and terminal phases of their trajectories.

Launch phase measurements are now nearing completion and, in Hall's words, the problem is becoming not one of data acquisition but of data reduction and analysis. The other two phases, and especially the Pacific Range Electromagnetic Signature Studies (PRESS) and the Tradex radar program are continuing.

• **Maneuvering re-entry**—The Defense Dept. is interested in maneuverable vehicle technology to permit the recovery of "men or information at costs competitive with other means to achieve the same result," Hall stressed. Plans are currently under way to develop this technology, and, should a need arise, to apply it to a ferry vehicle used in conjunction with an operational space station.

Although praising the *X-15* flight program and the technology derived from the *X-20,* Hall emphasized that unmanned spacecraft, such as *ASSET* and the Project *Fire* vehicle, can explore materials, heating and aerodynamic problems "that would not be appropriate to investigate with a manned vehicle because of safety considerations. It is our plan to make greater use of this type of program in the immediate future. It should be possible to acquire much of the needed information less expensively in this manner."

With the availability of *Titan III,* DOD "sees the possibility of flying multiple small re-entering devices to bring back data such as biological samples, materials aged in orbit and the like." For this reason, the flight regimes to be studied first are those associated with recovery of relatively small payloads (under 500 lbs.).

Second priority will be given to returning payloads of a size equivalent to potential ferry requirements. This requirement can stem from the need to recover either men or materials, "although the requirements are likely to be set by man and his protection," Dr. Hall said.

Interest also exists in the development of an ablation-cooled lifting re-entry body capable of "at least 600 nautical mile cross range maneuvering." Since configurations apparently exist to satisfy this requirement and at the same time offer adequate volume and weight capabilities, DOD is studying the desirability of testing one or more of these configurations.

• **Further effort outlined**—In order to "fill the voids in our present knowledge and understanding," Hall stressed that DOD needed increased effort in entry technology to:

—Develop less expensive radiative and ablative materials that can be easily molded and applied to spacecraft and aircraft structures in the field with a minimum of special tools, equipment and engineering assistance.

—Develop less expensive and less complex manufacturing and fabrication processes and techniques for utilizing refractory alloys.

—Find ways and means to reduce the launch services, refurbishment and testing costs associated with either usable or re-usable boosters and spacecraft. These are the major blocks to achieving a cost/effective re-usable system. ■

85-90% approved . . .

Minimal Design Changes Appear in First All-Metal Mockup of LEM

Exterior shows greater detail than previous plywood model; interior includes much more equipment, some of it prototypes

by David A. Anderton

BETHPAGE, N.Y.—Very few detail design changes characterize the M-5 all-metal mockup of the Lunar Excursion Module for the *Apollo* program.

Shown for the first time at Grumman Aircraft Engineering Corp.'s LEM facilities here Oct. 8, the M-5 mockup represents an engineering and manufacturing tool more than just a geometrically similar, full-scale model of the LEM.

Compared to the plywood mockup revealed earlier in the program, the M-5 shows more exterior detail and far more interior equipment and systems installations. In many cases, prototype equipment has been installed. Shape of the landing-gear footpad has been changed, and Grumman vice president Joseph Gavin pointed out that the new shape is consistent with design requirements estimated from *Ranger VII* data.

Details of several antennas have been altered since the wooden mockup was shown; changes are particularly obvious in the rendezvous radar above the crew compartment.

Gavin said that a further weight control program was under way, and that the LEM team is hopeful of maintaining a balanced tradeoff from now on so that the addition of new items or changes in existing equipment will be balanced by weight saved through the program. Grumman has exceeded its original basic weight estimate and used essentially all of the weight allowed in the LEM design. But most observers feel that the original weight estimates were not too realistic and were limited by performance of the vehicle rather than by the design requirements of the Lunar Excursion Module.

Dr. Joseph Shea, NASA's *Apollo* Program Manager and one of a group of space agency officials who spent a week at Grumman in a detailed criticism of the M-5, said that between 85 and 95% of the LEM design has been approved and that NASA is now checking some details after the mockup inspection. "The changes represent only minor problems," he added.

Gavin said the mockup represented the first set of metal parts released and fabricated for the LEM, and the first set through the fixtures built for the production program. Grumman will build nine ground-test vehicles and 11 LEM flight models.

● **Engines through jigs**—Both the first and second descent stages of LEM have gone through the jigs, and the first ascent stage has also been jig-fabricated. All routine shop procedures associated with production of any spacecraft, starting with the routing of drawings and ordering of raw materials and including complete quality control, have been used in the construction of the M-5 mockup.

Because of the difference in loads—Earth gravity is more severe than operational loads on some portions of the LEM—and because of the anticipated usefulness of the M-5 mockup, it is more ruggedly built than the LEM specifications demand in some areas. For example, Gavin pointed out, there are more rivets than necessary. The mockup will be updated from time to time as changes appear desirable or necessary.

● **Showing a puzzle**—Official showing of the all-metal mockup so soon after the presentation of the wooden mockup was a puzzle to many observers, who could see no particular reason for the effort. NASA's viewpoint was that this was a routine step in the *Apollo* program.

But one cynic observed that the press conference and the staged performance for TV and news cameras was part of the Administration's October Technical Revolution, and said that LEM really meant "Lyndon's Election Module." ■



What Moon Is Made of?

ALLIS-CHALMERS scientist Dr. Thomas P. Meloy shown with "fairy castle structure" developed to show how microscopic particles of lunar dust created by meteoroid bombardment may form sponge-like layer. Model is magnified 1,000 times.

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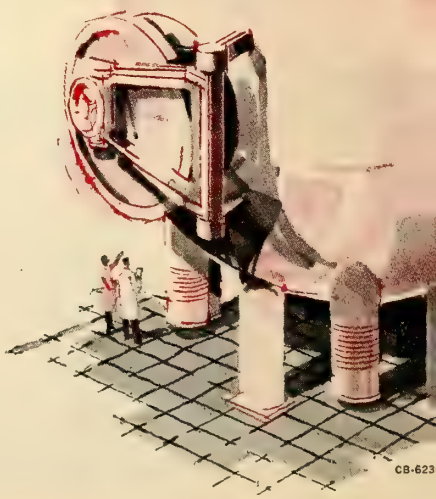
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Technical Countdown

ELECTRONICS

Laser Sound Waves Damage, Not Beam Itself

Damage observed in glass, quartz and sapphire after exposure to light from a high-powered ruby laser is caused by extremely-high-frequency (about 10,000 mc) sound waves generated in the materials. Dr. Concetto R. Giuliano of Hughes Research Labs told an Optical Society of America meeting that sound waves are the probable cause of damage to transparent materials subjected to laser beams—not heat, shock, radiation pressure or the beam itself. Giuliano says that in using today's high-powered lasers, these high-frequency sound waves travel in a forward direction through the materials, producing damage at the exit face. Tests pointed to sound damage as the only factor consistently supported by experimental evidence. The discovery may open a new area of laboratory research in the field of sound.

ADVANCED MATERIALS

Linde Sues Ryan Industries over Insulation

Union Carbide Corp. has initiated a patent suit against Ryan Industries, Inc., Cleveland, for infringements of U.S. Patents 3,007,596 and 3,009,601. Both patents cover the Linde Div.'s superinsulation. In a complaint filed in the Cleveland U.S. District Court, UCC is seeking an injunction to prevent future infringement and damages for past actions by Ryan Industries. UCC has established a licensing arrangement for the manufacture and selling of the superinsulation under the patents.

Fluxless Brazing at Avco

Thin-gauge aluminum structures can be brazed without using a flux through a new ceramic matched-die brazing tool perfected by Avco's Aerospace Structures Div., Nashville, Tenn. The manufacturing process has been used only on aluminum and aluminum alloy cold-plate structures, but the firm claims it is not limited to this type. In the process, a sealed, air-evacuated and inert atmosphere envelope containing the materials to be brazed is placed between reference platens and is not moved until the entire cycle is complete. The reference platens are integral heating and cooling areas within the ceramic work surface. The elimination of flux eliminates the possible corrosion problem encountered when brazing flux is not completely removed after a forming cycle.

Bronze-Plastic-Steel Seals Set Record

Seal rings of bronze, plastic and stainless steel have passed the 6,000-hr. mark in a liquid nitrogen pump without maintainance in what is believed to be a new performance record. The seals are in a Kobe triplex pump at Rocketdyne's engine test facility in the Santa Susana mountains of California. The special rings, designed by the Metal Products Div. of Koppers Co., Inc., are still in operation. Most sealing rings would be expected to fail after only 1,000 hrs. The K30M rings are bronze-filled Teflon backed by stainless steel to control tension. The average pressure is 5,000 psi. The facility is part of a nitrogen engine pressurizing system.

NRC Introduces Austrian Molybdenum

A new form of molybdenum with significant improvements in high-temperature performance is being marketed in the U.S. by National Research Corp., subsidiary of Norton Co. The HT molybdenum retains ductility for "appreciable periods" at 3,600°F. In wire form and depending on its diameter, the metal form has 30% to 70% greater tensile strength than conventional moly. NRC claims the new wire permits production of impact-resistant electronic tubes for the first time. Wires of the new form have been bent through 90 degrees without failure after being exposed to 3,450°F for 15 min. Ribbon and wire can be supplied annealed or unannealed by the Cambridge, Mass., firm. The HT molybdenum is a development of Metallwerk Plansee of Austria.

Tantalum/Columbium Material Marketed

Kawecki Chemical Co. is now marketing a set of new materials—tantalum and columbium coated with zirconium diboride—for high-temperature applications. The coating penetrates enough to form an adherent bond without adversely affecting the properties of either base metal. Initial uses are expected to be in steel and aluminum production as thermowells. The cost of the new product is about half that of zirconium diboride alone. The boride has considerable resistance to corrosion by molten metals while the tantalum and columbium backing retains strength at high temperatures.

PROPULSION

Solid Propellant Simulator Installed at Philco

An $80,000 rocket motor solid propellant simulator has been installed at Philco Research Labs' El Toro, Calif., facility. The simulator will extend the Ford Motor Co. subsidiary's ability to analyze, review and develop new propellant materials and components. The new system is now operational up to 5,000 lbs. thrust, and the ultimate 10,000-lb. thrust level will be attained early in 1965. The simulator is being used in support of research contracts on restartable and film-cooled nozzles. Philco's Aeronutronic Div. is using it for the development of large, hot-gas valves. The device reproduces identically the combustion products, composition and temperatures of a solid rocket while using liquids, gases or slurries. This approach is both economical and versatile in switching test parameters.

SPACE MEDICINE

He/O_2 Atmosphere Cleared for Sound

A study at the Air Force School of Aerospace Medicine into various gases for spacecraft atmospheres shows that sound transmission problems in a 50% helium/oxygen mixture at about 7.5 psi are not as great as previously supposed. While some modification of the tone was apparent to all subjects and observers, speech was reportedly not distorted beyond easy, accurate recognition.

Radiation Defense Succeeds

Three treatments for protection against radiation show "significant" protection against otherwise lethal doses of X-rays. All involve the use of AET (aminoethylisothiuronium dibromide) and cysteine in a homogeneous mixture. Monkeys treated with AET have survived as long as three years without gross effects. Others not protected and subject to the same exposure died soon after irradiation. The work was performed at the Air Force School of Aerospace Medicine.

ESRO Facility To Buy U.S. Equipment

Most hardware for new Technology Center will, however, be purchased from European firms; programs will require some new tracking stations

by William Beller

PARIS—The European Space Research Organization (ESRO), now forming its Space Technology Center (ESTEC), a small-scale version in the Netherlands of NASA's Goddard Space Flight Center, will buy some equipment —as well as some launch vehicles—for this facility from U.S. firms.

"It would be economically and even technically foolish for us to do otherwise," said a member of the ESRO staff.

Asked if such a buying policy didn't run against the spirit under which ESRO was organized, Prof. Pierre Auger, ESRO's Director-General told MISSILES AND ROCKETS "There is no formal or informal agreement regarding elimination of non-member states from contracts—nor will there be, even with respect to personnel."

One reason given for ESRO's "open-market" policy is the desire of member states to get as much space experience and data as possible for every franc spent. Furthermore, the organization will have to pay for *Scout* launches of the relatively small *ESRO I* and *ESRO II* satellites, and possibly for *Thor-Delta* launches of medium-sized satellites.

For the large astronomical observatory that ESRO contemplates putting into orbit as part of its eight-year plan ending in 1972, an ELDO (European Launcher Development Organization) launcher may be used. If this doesn't work out, "we may buy an *Atlas-Agena* launch," said an ESRO spokesman.

Part of the experience European companies expect to get out of ESRO is in designing and developing space hardware—even though, in some instances, it may be a little cheaper to buy the same hardware in the U.S. This is what lies behind Auger's remark, "We will, of course, try to promote European industry in this field." Nevertheless, European firms will not be allowed to write their own sales tickets, Auger stressed, because "the companies will have to be competitive with U.S. companies."

• **Wherewithal**— ESRO was formally established this past March 20. Before the end of the year, Italy is expected to ratify the ESRO agreements, already signed by Belgium, Denmark, France, the Netherlands, Spain, Sweden, Switzerland, the United Kingdom and West Germany.

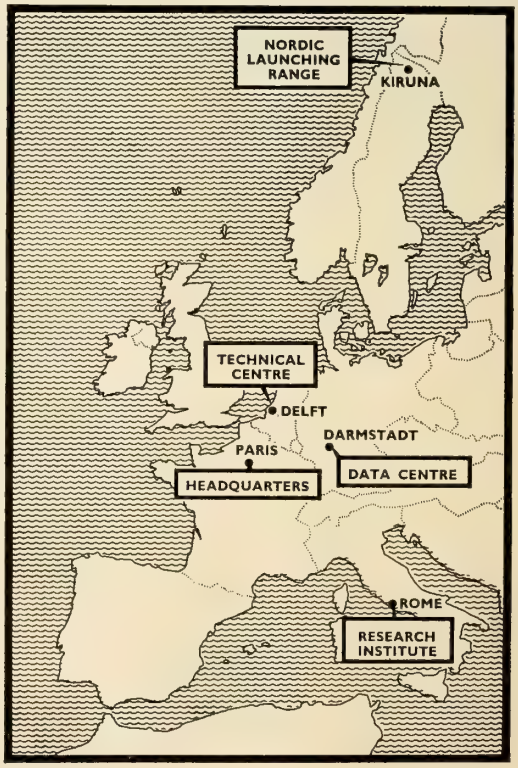
The financial ceilings set by these agreements are well known. They are not to exceed $76 million for the first three years of activity; $120 million for the second three-year period; and a total of no more than $300 million for the entire eight-year period.

The bulk of the money will be put out to contract and monitored by ESTEC. It will have a staff of about 800, mostly engineers and scientists. They will study and develop rocket payloads, satellites, probes and the related technologies.

• **Chambers**— "The environmental test facility we intend building in Delft probably will be the best in Europe," said Dr. A. W. Lines of the United Kingdom, ESRO's technical director and also head of ESTEC. This does not mean ESTEC will be building large environmental chambers such as those installed at Goddard. "We are not sure we need them," said Lines, "in fact, we're not sure what answers they give, how useful they really are."

Lines hastened to add that Goddard was "certainly right" in deciding to build its large chambers. "Somebody had to do it to find out their usefulness—and I'm glad it was NASA because now we don't have to spend the money."

Environmental testing of spacecraft probably will be centralized at ESTEC for all applicable European work. Lines sees no reason for building such specialized facilities elsewhere, "anymore than one would wish a proliferation of specialized wind tunnels." In the near future, ESTEC plans to build two relatively small chambers, each about three meters in diameter, chiefly for vacuum and solar simulation work. Requests for



FACILITIES of the European Space Research Organization.

proposals have already gone out for this work and contractors are expected to be chosen sometime this fall.

ESTEC also expects to place a large order for rocket-borne telemetry (M/R, Oct. 12, p. 9). Meanwhile, ESRO is said to be considering placing satellite tracking stations at Fairbanks, Alaska, the Falkland Islands, Spitzbergen (Norway) and Belgium.

● **Operations and contracts**—When a rocket, payload or satellite is settled upon, ESTEC will see that the program is carried out. As scientists suggest experiments, the best will be selected by a committee of scientists; these experiments then will be combined into appropriate payloads.

All the experiments making up a payload for a satellite must contribute to a single scientific mission. "This surely makes sense," said an ESRO staff member, "because it would be foolish to measure, say, the Earth's radiation belts with a satellite also serving as a topside sounder." He explained that it would be better to complement the radiation-belt experiments with ones sensing solar phenomena, aurorae, and particle precipitation.

Although the syndrome of experiments is put together by science committees, ESTEC sees not only that the satellite is produced but also that all supporting work is done: on-board power supplies designed and installed; tracking and telemetry ordered, developed and adequate; experiments themselves designed to fit into the satellite.

Sensors for the experiments will usually be produced by the scientists. ESTEC, in turn, will prescribe the needed rocket or satellite parameters, put the hardware specifications out to industry, and help develop the components that don't exist. "Most of the development work, and all production work, will be done by industry," according to ESRO.

In the strict sense, the actual contracting authority lies in the Council of ESRO nations, particularly in its Finance Committee. A simple majority of the Committee, or Council, approves the contracts. In practice, ESTEC recommendations are expected to prevail.

● **ESRO II first**—*ESRO I and II* are occupying most of ESTEC's attention. Bids are now coming in for *ESRO II*, and within about six months requests for proposals for *ESRO I* will be going out. Both *ESRO's* will be launched by NASA, probably by the end of 1966 or early in 1967, from the Pacific Missile Range.

The reason *ESRO II* is scheduled to be launched first is its payload can be developed faster than that of *ESRO I*. To avoid confusion, ESRO experimenters say they will soon change the names of their satellites accordingly.

RFP's for *ESRO I* are based on individual preliminary design studies of the satellite made by SAAB in Sweden and the Center of Space Research (CRA) in Italy. Although it is difficult to tell before the bids are in what the worth of the *ESRO I* contract will be, an ESRO official said it would fall between the wide limits of $1 million and $10 million. Several satellites will be called for: one for mockup and placement of equipment, and others for electrical and environmental checkout, flight and backup.

● **More tracking needed**—ESTEC is going to have to expand the tracking and telemetry facilities that the French Space Agency (CNES) will be furnishing to ESRO through a rental arrangement. At least four more stations will be needed for adequate coverage, chiefly because the *ESRO* satellites will be in near-polar orbits while the CNES stations are designed to cover near-equatorial orbits.

A final decision on where the stations are to go is expected very soon because the entire network will have to be operational by the time the satellites are launched.

The temporary accommodation for ESTEC is at Delft Technical University. The Center will soon erect its own buildings, probably in the Delft area, although this is not completely certain. A decision is expected by the end of the month.

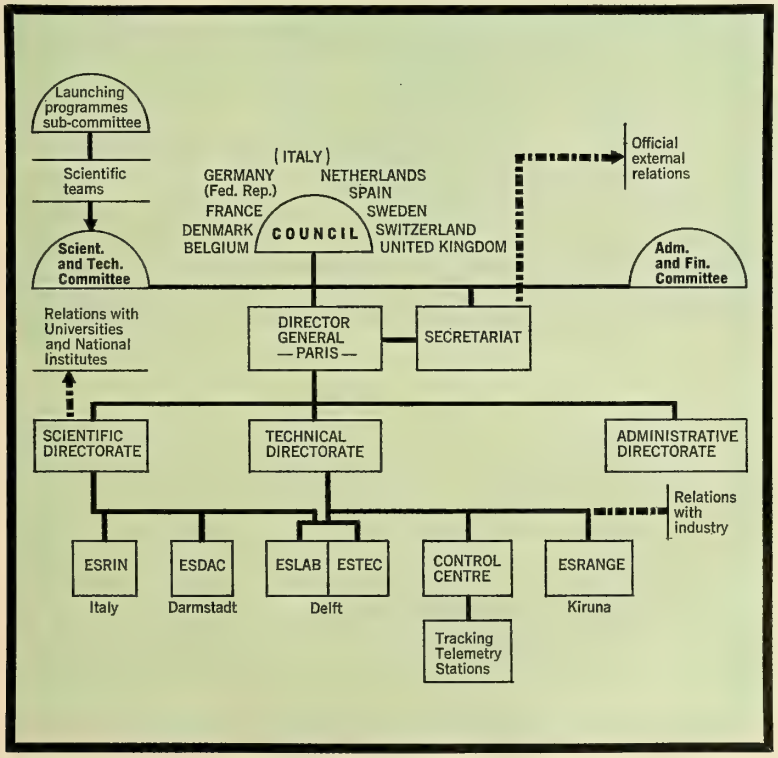
● **Other installations**—ESRO has several other operating or soon-to-be-operating facilities, but none with the contracting responsibility of ESTEC. In the works are:

—A small laboratory (ESLAB) to be established in the vicinity of ESTEC, where scientists from member states will be given the opportunity to work as fellows for a limited time on certain space projects.

—A Data Center (ESDAC) to be established at Darmstadt, Federal Republic of Germany. Its staff of scientists and engineers will be concerned with the problems connected with data processing and analysis, and with fundamental questions associated with orbit prediction and analysis.

—A Research Institute (ESRIN) planned to be established in Italy, devoted to advanced research, particularly concerning physical or chemical phenomena, occurring in space.

—A launching range for sounding rockets (ESRANGE) to be established in the vicinity of Kiruna, Sweden. The location in Lapland, approximately 100 kilometers north of the Arctic circle, has the advantage of a high geographical and a high geomagnetic latitude, making it particularly suitable for certain geophysical studies. ■



ESRO management structure. (Italy is expected to be a member by end of 1964.)

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Project Forecast Recommendations Reshaping AF Bioastronautics Effort

by Heather M. David

THE AIR FORCE'S bioastronautics work on closed-cycle atmospheric validation has been speeded up and its extravehicular protection program considerably reoriented as a result of recommendations from Project Forecast.

Lt. Col. Stanley C. White, USAF (MC) indicated that the entire Air Force bioastronautics effort is being reshaped in accordance with recommendations made by the technical panel charged with setting objectives for the next 10 years of Air Force research and development.

Some of the changes particularly significant to industry are:

—A speed-up of studies on two-gas atmospheric systems for spacecraft.

—A major reorientation of the Aerospace Medical Division's (AMD) program for extravehicular capability, to satisfy the development of suits with thermal and pressure protection with good mobility and with propulsion devices.

—A considerable reorientation to "further strengthen" in-house AMD efforts in the area of water, food and waste management.

The Air Force Aerospace Medical Division, the division of the Air Force Systems Command responsible for the Air Force bioastronautics and space medical work, has aligned its structure to meet the objectives, White told a group meeting recently at AMD headquarters at Brooks AFB, Texas.

● **Biologistics**—Besides the increased emphasis on study of two-gas systems, more work is being done on the identification and effects of contaminants.

In the extravehicular category, in addition to a reorientation in development of suits, effort is being directed to tethering techniques.

In the general area of life-support systems, the Air Force has integrated its efforts with NASA, and is concentrating on those areas for which it has a sole need, White pointed out. This includes systems for the long-endurance aircraft, which was a specific development objective listed in Project Forecast. While NASA has given adequate development to two- and three-man 14-day space missions, White said, the Air Force has directed its research to those crew sizes and mission durations defined in Forecast.

Additional efforts, he said, will be made in systems for water recovery from urine. White said that since NASA has done so much of the technology for food requirements for *Gemini* and *Apollo,* the Air Force can thus concentrate on longer mission requirements, for long-endurance aircraft and the longer space missions.

● **Biomechanics**—White said that Forecast did not list specific new ideas for R&D in this area, but recommended continuation of present AMD programs. In this line, he said, development of criteria and protection against multiple stresses in escape systems will be emphasized in the sustained acceleration studies.

Emphasis has also been given to effects of large-amplitude simultaneous excursions in rotational as well as translational forces. This is directed at the requirements of low-level, high-speed aircraft and counter-insurgency (COIN) operation such as in aerial delivery and pickup of personnel.

Techniques have been refined in the area of noise problems. It was determined that most of these could be solved. This includes increased work in effects of infrasound—high-intensity low-frequency pressure pulses—such as those produced by large boosters.

● **Neurophysics**—At the time of the Forecast study, the bionics program being conducted at Wright-Patterson AFB laboratories was the only Air Force effort in neurophysics. However, a "substantial" program was suggested and White said that careful study is being made to develop plans.

● **Bio-effects of photo-thermal energy**—AMD has initiated a program to investigate the biological effects of lasers and masers, including both intentional uses and accidental exposures. Increased emphasis is being given to eye protection against flashblindness from weapons, and for space situations, since no satisfactory protective device has been developed.

● **Bionucleonics**—A program to determine the neutron effects of low-yield weapons has been initiated, and more work is being done to obtain tolerance data to prepare for "the probability of nuclear propulsion for long-endurance aircraft."

Work is being continued on prophylaxis and therapy, and the development of time-release capsules for drugs that may be radioprotective. In this area, "applicability for use in manned spaceflight has been emphasized," according to White.

The AMD animal colony research will continue, with emphasis on the nuclear propulsion effects. Proton studies have been increased, and accelerators are now being used to determine effects of solar flares.

● **Aerospace medicine**—AMD has already contracted with Aerojet-General Corp. to increase its in-house capability for studying the toxicology of propellants and other materials, a field emphasized by Forecast. The division has also initiated a program using a cytological approach to toxic effects, a suggestion from the study.

Other fields in aerospace medicine being enhanced as a result of Forecast are a program of epidemiology for limited war and COIN situations, and self care for both limited war/COIN and for space emergencies.

White said that internal realignment has taken place in the Aerospace Medical Division to meet the challenges of the Forecast study. For practical management, however, research is documented in six technical areas of life support, aerospace medicine, radiobiology, human performance, basic biological sciences and bioastronautics and systems support.

The first five areas are self explanatory. White said that bioastronautics and systems support has been established to perform technical liaison between elements of AMD and other agencies. The assignment of a group headed by Dr. Andres Karstens to the systems program office for the Air Force *Manned Orbiting Laboratory* (*MOL*) is an example of this relationship. ■

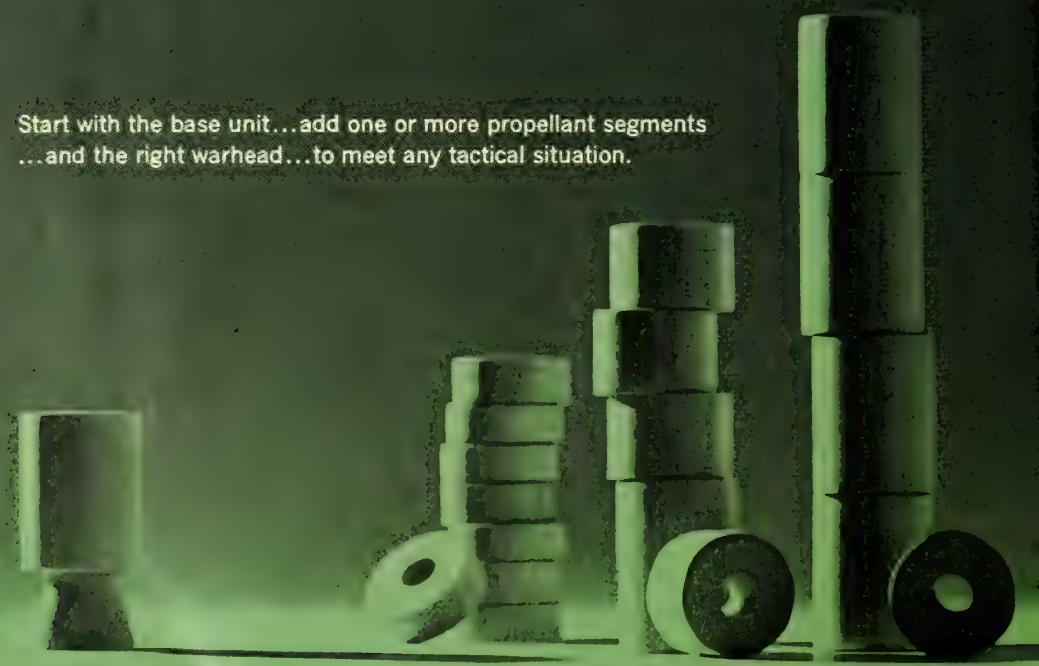
FROM LOCKHEED'S TALENTED WEAPONS TEAM:

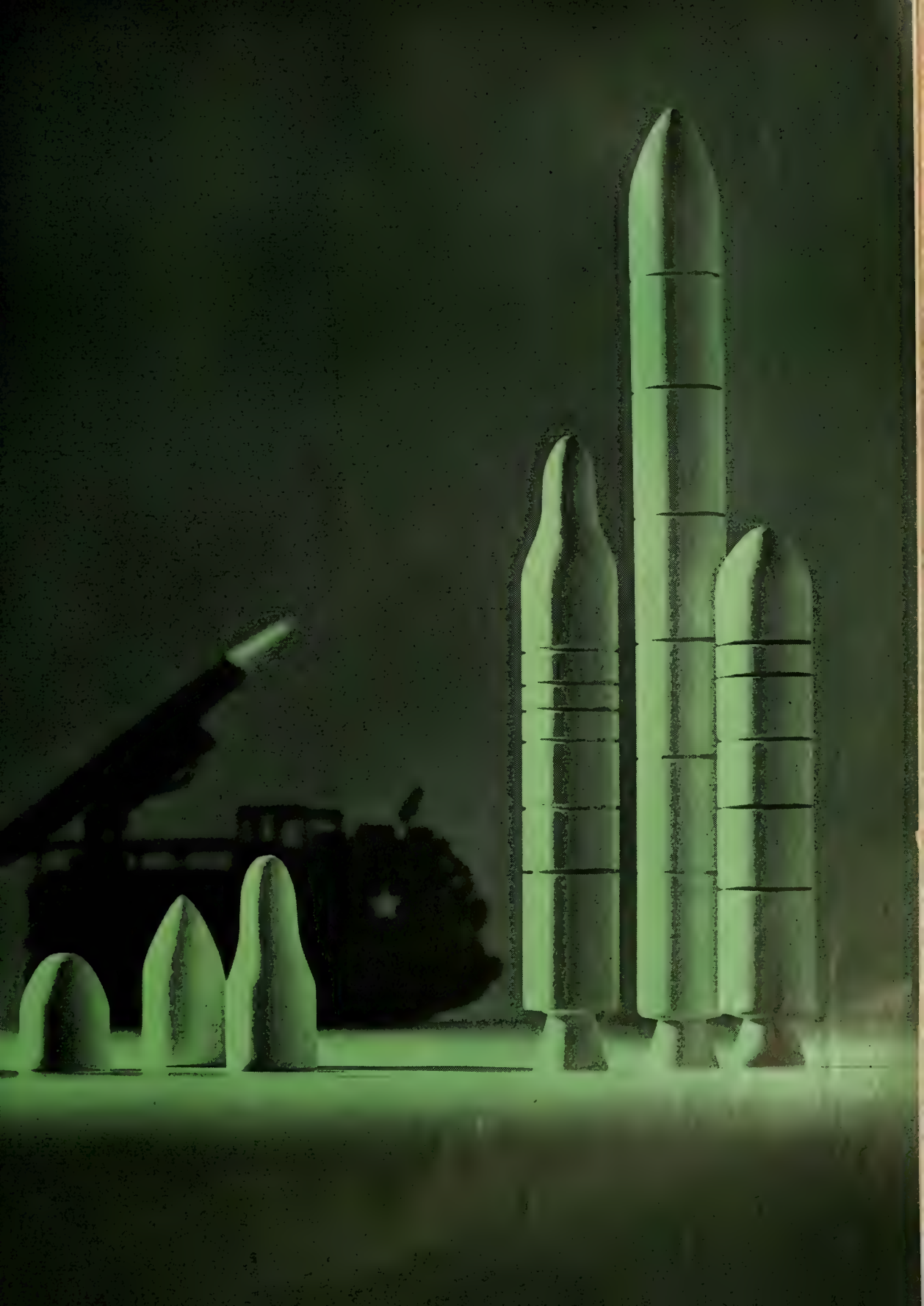
A "building block" tactical missile

Here's a challenging new idea from one of America's foremost missile teams: a modular missile that would permit, from land or sea, swift response to any tactical situation. It could be assembled quickly at the scene of action to hurl a wide variety of payloads at targets from one to fifty miles away. It would speed up training, increase effective firepower, improve accuracy, and simplify logistics. ■ The company which designed and built the U.S. Navy's Polaris missile now is seeking solutions to many of the new problems that confront the Armed Forces in a fast-changing world. Here in one compact organization is the talent to define a problem, find the best solution, and turn concept into hardware—in minimum time, at maximum cost-effectiveness. ■ Lockheed Missiles & Space Company, Sunnyvale, California: A Group Division of Lockheed Aircraft Corporation.

Lockheed

Start with the base unit...add one or more propellant segments ...and the right warhead...to meet any tactical situation.





AF Starts Tests of Its 'Most Perfect' Antenna

Newly dedicated Haystack X-band system is major advance in high-power microwave radars, will perform many roles

TYNGSBORO, MASS.—The Air Force has begun performance tests of a huge $15-million facility described as "the most prefect X-band antenna of large size in the world."

The Haystack Microwave Research Facility (M/R, March 23, p. 26) will be able as a radar to skin-track an unaugmented 1-sq.-meter target out to ranges of 16,000 mi. Even more important, it will be able to see a target with three orders of magnitude less cross-section at 2,000 mi.

Basically, the system, dedicated here on Oct. 8, is a multi-purpose research facility comprising a 120-ft. steerable antenna and transmit and receive subsystems—for use in radiometry, space communications, radar and satellite identification and analysis. It is expected to provide one of the greatest advances ever attained in high-power microwave radars.

Operating basically at 10 Gc, the system will yield a half-power beamwidth of 0.05 deg, a maximum pointing error on the order of ± 0.005 deg, a theoretical gain of about 67-68 db, and an initial overall systems temperature of 70-80°K. The latter figure is expected to drop to about 30°K with installation of a new cryogenic maser amplifier now under development at the AF's Lincoln Laboratories. The initial system will use a cooled parametric amplifier.

The dish also is expected to be used for radio astronomy work at frequencies as high as 35 Gc into the millimeter regions with even sharper beamwidths. Scientists at Lincoln Labs believe that components now used in the smaller-millimeter system at the Labs could be adapted to Haystack.

● **Changeover**—Haystack is converted from a radiometry role to an active radar or communications system by means of plug-in transmitter boxes which can be interchanged in place behind the dish, thus reducing waveguide requirements and rotary joints.

Two basic boxes have been developed. Wide-band radio receivers operating at 5, 8 and 15.5 Gc have already been installed in the radiometry box. Others operating at 35 Gc, 1420 mc and 1670 mc will be added. The radiometer box is already installed and operating in the Haystack structure.

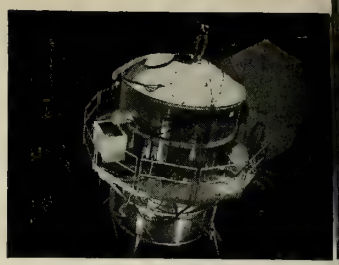
The radar/communications box will be a CW X-band system with 100-kw output. Haystack is also spurring development of even higher-powered CW and pulsed transmitter tubes, particularly by Varian Associates and Eitel-McCullough, Inc. The radar box is expected to be hoisted into place in about a month.

● **Check on Westford**—In addition to its other roles, Haystack will add to the AF evaluation of its *Westford* orbiting dipole belt. While the service is convinced that this concept works, it wants more data on pattern and dissipation characteristics. *Westford* has "thinned out substantially" since it was launched about a year and a half ago, one scientist told M/R, but "is still adequate for narrow-band communications." He said the belt "is petering out according to plan."

Gen. Bernard A. Shriever, commander of Air Force Systems Command, who dedicated the facility, told a press conference that the Air Force has not asked for an operational *Westford* belt.

● **Special praise**—At the dedication Schriever singled out North American Aviation, Inc., which built the massive antenna system to a maximum surface deviation of ± 0.075 in., and the H. I. Thompson Fiber Glass Co., which effected major innovations in the space-frame radome that encloses the Haystack radar, for special praise among the many contractors associated with the Massachusetts Institute of Technology/AF Electronic Systems Div. project.

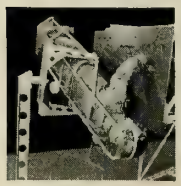
A sidelight of the Haystack development is in the computer programs developed to accomplish a very complex stress analysis of the high frame. The program developed by IBM for such problems was first applied to Haystack on a large systems scale. It is now believed that IBM will announce shortly the availability of FRAN (Frame Analysis) as a new and commercially available program for similar projects. ■



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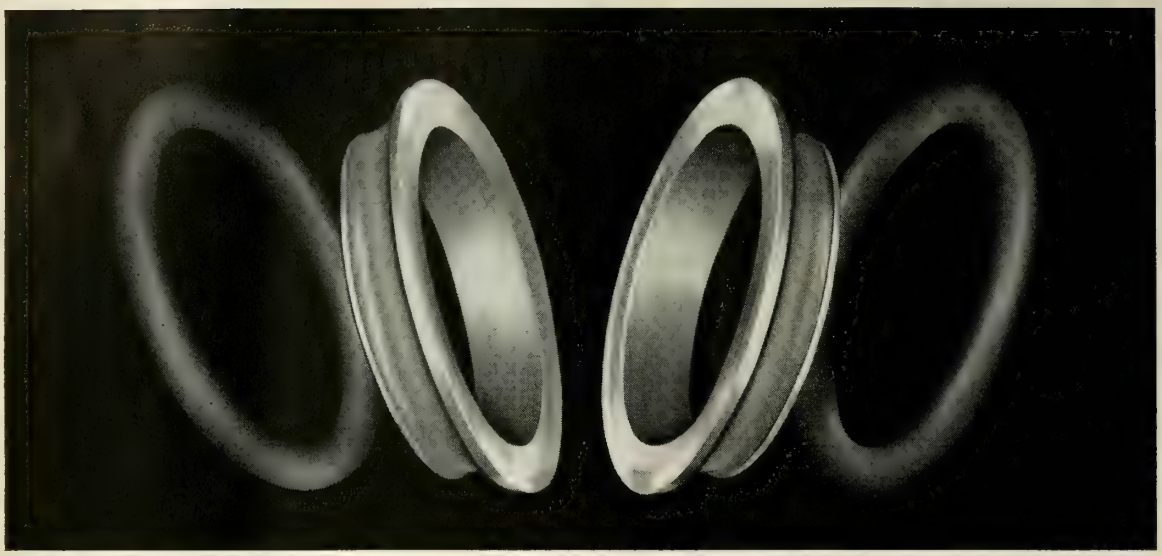
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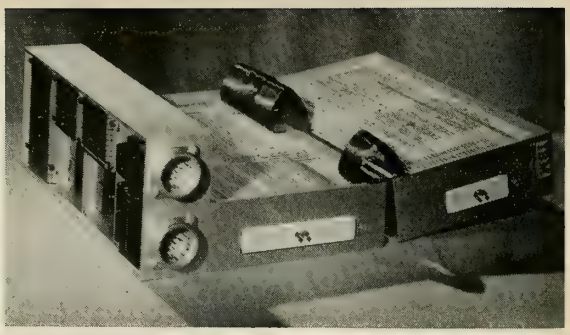
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THIS SINGLE 26-lb. all-thin-film-circuit digital computer (left) was built for the Navy's Bureau of Weapons to prove the applicability of automated thin-film production to flight subsystems.



Although employing advanced design, IBM concurrently began development of a more advanced 15-lb. computer (mockup at right) using improved thin-film circuit design.

space electronics

Sophisticated Thin-Film Computer Holds Aerospace System Potential

By Charles D. LaFond

OWEGO, N.Y.—A state-of-the-art, thin-film, digital computer for possible use in advanced aerospace systems is nearing final development at IBM's Space Guidance Center here.

Weighing 15 pounds and occupying about 0.2 cu. ft., the experimental system will require only 30 watts total power in operation.

A developmental outgrowth of a 26-lb. digital computer built by IBM's Federal Systems Division for NAFI, the Naval Avionics Facility in Indianapolis, Ind., the new highly advanced thin-film computer is due for completion by mid-February, 1965.

Providing a 1,920-word memory (26 bits each plus parity), the system will employ a random-access core memory. Dual-aperture ferrite core construction permits non-destruct readout.

Upon completion and test of the tiny prototype computer, engineers at the Space Guidance Center expect to build a second system of similar design, using semiconductor integrated circuits. The two systems will then undergo extensive bench testing during the following year to provide a comparison of the two fabrication techniques.

● **Shrike-type computer**—The earlier system was designed for NAFI as a *Shrike*-type missile and bomb-delivery guidance computer.

Not necessarily intended for early use with the anti-radiation missile system, the computer, designated Mk9Mod3, was developed to prove out the production capability of a semi-automatic thin-film production system developed by IBM in 1962 for NAFI. It will, however, be tested by NAFI to compare performance with the four-times-larger Mk9Mod1 *Shrike* analog computer developed by Navy Ordnance Test Station, China Lake, Calif.

The recently delivered NAFI computer was developed under a $650,000 contract awarded to IBM in June, 1962. Only one system was ordered and built. (Funds were limited at that time, according to the Navy, which stressed that it primarily wanted to test the production capability of its thin-film vacuum deposition production system in a practical application.)

The NAFI computer measures 11.5 x 10.4 x 3.4 in., occupying about 0.25 cu. ft. of space and weighing 25.75 lbs. Total power consumption is 102 watts.

A general-purpose computer, it carries an 1,184-word (18 bits each) permanent ferrite-core memory and is capable of processing 25,000 instructions per second. Eighty thin-film active circuit panels (containing up to 32 circuits each) perform all the arithmetic, logic and memory drive functions. The system employs a binary, parallel, single address computer mode.

Principal subsystem elements of the computer include a 10-bit analog-to-digital converter, ferrite-core memory, sense amplifier, and prime power supply.

Basic oscillator speed is 1.81 mc and memory cycle time is 8.8 μsec. Average computation cycle times, said IBM, are as follows:

—Initial program loop (33.5 msec.)

—Pull-up program loop (20.7 msec.)

—Final program loop (260 μsec.)

The basic NAFI computer thin-film circuit is a transistor-resistor NOR logic element. Logical functions are obtained from the standard circuits by varying logic interconnections between circuits and active elements.

● **NAFI to test**—The *Shrike*-type computer has been delivered to NAFI, and upon successful completion of bench testing at the Indianapolis facility, the system will undergo extensive simulation tests and eventually some flight tests.

IBM testing of the Mk9Mod3 has been minimal. Thin-film circuit panels have been given moderate environmental testing. No tests at Owego have been carried to destruction.

(Continued on p. 35)



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It was clear that oscillography had a new champion. The story of the 5-133 is one more important reason why CEC has become the leader in the development of all phases of data recording.

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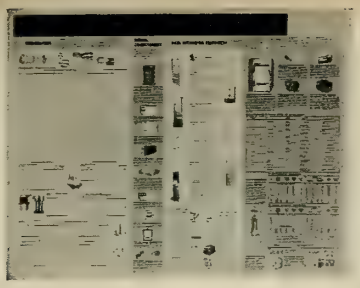


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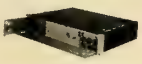
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Sensors and Pickups
Chart shows the 43 available for pressure, vibration, acceleration.



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Chart shows 11 basic types and where they may be required.





Magnetic Tape
Chart shows 8 analog and digital recorder/reproducers with support equipment.

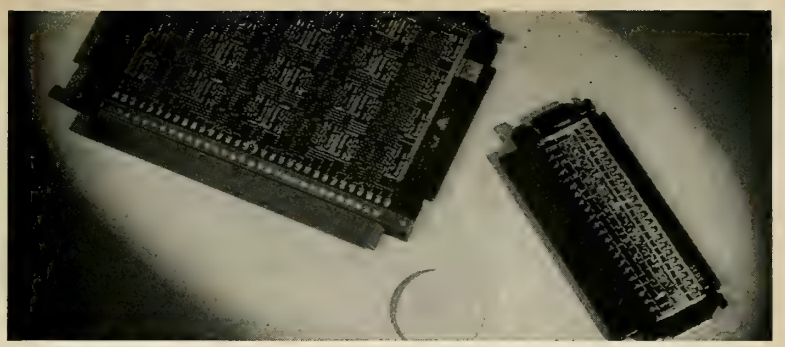
Direct Readout
Chart shows 5 recording oscillographs, 33 galvanometers and where they can be used. Also support equipment.



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NAFI COMPUTER thin-film circuit panel comprised of 32 circuits is shown at left. A 24-circuit thin-film panel (right), now under development by IBM, is one-fourth the size of the 32-circuit panel through use of a simplified interconnection pattern and a great increase in film-pattern density.

NAFI will simulate aircraft operational inputs and bomb-delivery constants, rather than *Shrike* equations, to exercise the computer. This will be the first implementation by the Navy of such formulas for digital computation. Inputs will be generated by an analog computer.

NOTS, China Lake, reportedly, will flight-test the system eventually by pod-mounting the device beneath an F4D aircraft.

● **Panel-size reduction**—The basic component in both IBM computers is the passive thin-film circuit panel with patched-on active elements.

The *Shrike*-type system uses 80 panels including 29 different types. Each panel contains 32 circuits and up to 160 discrete parts on each panel plus interconnections. This is a parts density equivalent to 125,000 per cu. ft.

Two panels are prepared at a time in IBM's production system on one 0.016 x 2.5 x 4.0-in. substrate.

However, for the new computer system, each panel contains 24 circuits, and 16 panels are produced on a substrate measuring 0.016 x 3.75 x 5.187 in. Finished panels including connectors measure only $2\frac{3}{16}$ x $1\frac{5}{16}$ in., or about one-fourth the size of *Shrike*-computer panels.

● **Automated deposition**—Development of both computers goes back to a Navy desire in 1961 to develop a semi-automated thin-film deposition production system and the need to establish such an industrial capability.

In July, 1961, NAFI (through the Navy Bureau of Weapons) awarded IBM a $530,000 contract to build the needed automated vacuum deposition line. The system was delivered to NAFI in August, 1962.

Later, IBM built a second system, now located at its Owego facility, for its own use.

The original NAFI requirements stipulated that either IBM market its system or select and assist another manufacturer in setting up the capability to produce the system. Consolidated Vacuum Corp. agreed to build and market the equipment on a custom basis.

Essentially the system is an in-line four-chamber vacuum deposition unit. Magazine-fed, it holds 24 substrates.

All passive components, insulation, and interconnection paths are applied to the glass substrates by vacuum deposition. Two runs through the four chambers are required to complete the passive circuit structures, employing up to eight successive film depositions. Transistor chips are soldered on later to complete the network.

Resistors are valued and later trimmed to within 2% of design value.

Three basic materials are used in the deposition process—silicon monoxide (SiO), chromium (Cr), and copper (Cu). Film thicknesses range as required from 300-30,000 Angstroms.

The deposition sequence for each chamber on each run is as follows:

First pass: (1) SiO, total substrate undercoating for uniformity; (2) Cr-SiO, mask and resistor deposition, widths carefully controlled; (3) SiO, mask and resistor overcoat, heavy resistor ends exposed for length control; (4) Cr-Cu, mask, overcoat, photo-etch Cr, then electrically etch Cu.

The first electrical tests and measurements are then performed and resistances modified (by reducing values) during an annealing process at 400°C. Resistors are stabilized within ± 8%.

Second pass: (1) SiO, insulation at all crossovers for interconnections; (2) Omit; (3) SiO, mask, staggered insulation to round off for jumpers; (4) Cr-Cu, crossover jumpers applied.

Semiconductor chips are then connected by solder reflow. Connectors are installed. Test, electrical trim of resistors and final test and measurements are made, completing the panels.

Current yield figures have not been released by IBM or the Navy. However, an overall yield of 16.5% was declared typical by one IBM spokesman for the system a year ago. ■

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Gauging Trails Vacuum Chamber Capabilities

by John F. Judge

THE TASK OF accurately and realistically determining the pressure in an ultra-high-vacuum chamber is now almost as much of a development program as the creation of the vacuum itself.

Scientists at the National Research Corp. are developing an approach to reliable pressure measurements based on advanced gauges and using extrapolations from a calibrated flow technique.

The drive for more realistic space simulation ability in various programs has resulted in the development of efficient vacuum systems with the current ultimate being the XHV (Extreme High Vacuum) System now being marketed by the Norton Co. subsidiary.

The system, developed by NRC more than two years ago, routinely produces pressures lower than the present limit of gauge technology. NRC researchers say it is theoretically possible that pressures much lower than 10^{-15} torr have been produced.

Ultra-high vacuums are being used to probe the unpredictable effects of low- and no-pressure environments on the materials, electronics and other components of space systems.

The space environment simulated in the NRC XHV chamber is so free of gases that a molecule would travel an average of 30 million miles before colliding with another molecule.

The system is 7 ft. long and 3 ft. in diameter, with a working region about half this size. The design principle can be used to construct larger facilities operating in this pressure range.

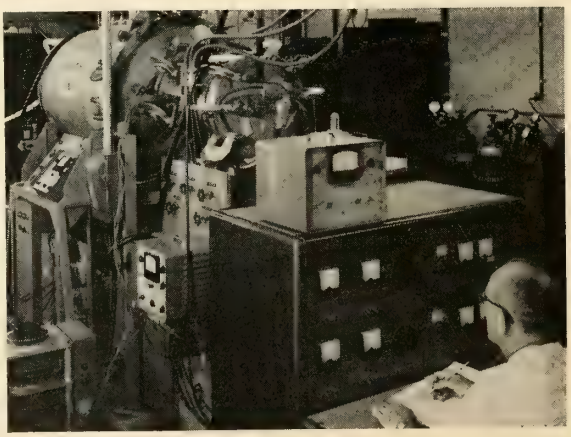
A combination of baking and cryogenic techniques keeps outgassing from the chamber walls to a minimum. The pumping system uses NRC oil diffusion pumps with cold caps and liquid-nitrogen-cooled baffles to eliminate back-streaming.

Additional pumping capacity is provided by keeping surfaces in the chamber at cryogenic temperatures—making it possible to condense gases given off by materials and devices being tested.

The first production XHV system has been installed at NASA's Manned Spacecraft Center in Houston, by NRC Equipment Corp.

● **Measurement limit passed**—No presently available commercial ultra-high-vacuum gauges give dependable readings below 10^{-13} torr. At this pressure, the gauges are being employed to the limits of their capability.

Recently, NRC researchers developed and tested a calibrated flow technique for cross-checking the gauge measurements. In addition, more reliable estimates of the pressures present in the XHV system beyond the gauge limits have been obtained. The gauges used were a standard NRC Readhead gauge



NRC-XHV prototype is being used by researchers to probe both vacuum effects on components and the problems of accurate measurement of pressures below 10^{-13} torr range. This system is known to far exceed the ability of available vacuum gauges.

and a specially-designed inverted magnetron. Both gauges were also used to obtain reliable measurements down to about 3 x 10^{-13} while purposely admitting helium to the system.

The pressures beyond this range were estimated by NRC experts on the basis of the known pressure drop associated with the flow of helium through a capillary. The helium was admitted to the XHV system through an accurately dimensioned capillary from a separate vacuum system, which operated at pressures down to 10^{-9} torr with a continuous helium throughput. Measurements of the pressure ratio showed that pressures in the extreme high vacuum portion of the chamber were directly proportional to the pressure at the inlet side. From measured values of the inlet pressure, the pressure in the XHV chamber was estimated to be 8 x 10^{-15} torr (nitrogen) at the cut-off point of the helium flow.

Theoretically, it is probable that the pressure reached in the XHV system is considerably below the indicated 8 x 10^{-15} torr range when no gas is purposely admitted to the system.

In the present work at NRC, the experimental chamber of the XHV was maintained at 10°K. At this temperature the equilibrium vapor pressure of nitrogen is approximately 10^{-16} torr. The vapor pressures of all other compounds and elements except hydrogen, helium, and neon are lower than 10^{-16} torr at 10°K.

Consequently, if hydrogen, helium, and neon are excluded from the system, pressures of less than 10^{-15} should be attainable without diffusion pumping. In correctly designed systems phenomena such as cryosorption and cryotrapping can be used to increase the effectiveness of the diffusion pumps. Hence, it is possible to maintain pressures considerably below the equilibrium values of the vapor pressures of the component gases in the system.

The cross-checking of gauge performance with the calibrated pressure ratio technique was begun at pressures of about 10^{-10} torr. The pressure ratio between the inlet system and the XHV chamber was measured experimentally with two similarly structured Bayard-Alpert gauges. The ratio measured was independent of the pressure level and in agreement with theoretical values.

Even when the XHV system is operating at immeasurably low pressures, the magnetron type gauges used continue to operate—although with exceedingly small ion currents. This is confirmed by measuring the rate of gauge response when very small pulses of gas are admitted to the XHV chamber. The gauge response is limited by the rate of gas addition. If the gauges were not operating, measurable intervals would elapse before the gauges restarted. ■

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Let's consider the basics of honeycomb in order to categorize the functions for which it can be useful. First let's define honeycomb and review its geometric characteristics. From this, then, we can consider the functions of honeycomb and the materials available to best meet the application.

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Honeycomb is a continuum of uniform two dimensional geometry which can extend infinitely in the third dimension.

GEOMETRIC CHARACTERISTICS:

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2. It is a composite of parallel, uniform cells sharing common walls.
3. It has high surface area to volume.
4. It has high free area to volume.

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- Surface Reaction
- Heat Exchange
- Separation
- Metering or Counting
- Cushioning
- Conduction
- Vibration Damping

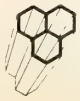
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Mercury spacecraft was built of titanium. It is natural that McDonnell, which built Mercury, should use titanium for Gemini... seven different grades to meet specific mechanical needs. No limitation in size either. Forged rings, for example, are as large as 96 inches in diameter; sheet as thin as 0.010 inch.

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Re-entry from Mars Is Major Problem

AIAA meeting told that technology for unmanned planetary entries is well in hand; NASA officials outline needs for future projects

by Michael Getler

WILLIAMSBURG, VA.—Continuing definition of flight requirements for planetary missions indicates there is some caution regarding extremely high-speed Earth-atmosphere re-entry for manned spacecraft and optimism as to the entry technology of unmanned planetary orbiters and landers.

Both attitudes were in evidence last week at a well-attended three-day conference on Entry Technology sponsored here by the American Institute of Aeronautics and Astronautics. The meeting produced a heavy emphasis upon technology required for various Earth-Mars exploratory craft, reflecting a realization that both the commitment and the funding for large-scale efforts in this field are no longer in the distant future and that the time has come for more serious study of detailed flight problems.

The note of caution was struck by Rodney Wingrove, research scientist from NASA's Ames Research Center. He pointed out that for Earth re-entry speeds of 70,000 fps, which could possibly be encountered in a manned spacecraft return from planetary distances, a roll maneuver must be initiated during a one-second interval (with a maximum spacecraft roll rate of about 20 deg/sec.) to insure capture by the Earth's atmosphere without exceeding a 10-g acceleration limit and without danger of skipping back out of the atmosphere.

While speeds of 70,000 fps are the maximum that can be expected, if they are encountered the critical timing of this flight maneuver would dictate automatic entry control systems, taking this role out of the hands of the pilot. This also would sharply reduce the possibility of pilot-operated back-up systems, and would therefore impose a very high reliability factor on the automatic system.

From re-entry speeds of about 36,000 fps, such as *Apollo* re-entry, up to interplanetary returns to about 60,000 fps, Wingrove says, piloted maneuvers are feasible, though they get progressively more demanding. At *Apollo* speeds about a 10-sec interval for the roll maneuver is available.

Above 60,000 fps—into the so-called "extreme supercircular" velocity range—it appears that new very-high-speed on-board digital computers will be required to properly time the critical roll maneuver, which essentially provides the negative lift required for a spacecraft to maintain equilibrium and not skip out of the atmosphere. This latter danger would occur if the roll were initiated too late. Starting the maneuver too early, says Wingrove, would probably increase the peak acceleration on the crew.

● **Ways around**—Wingrove emphasizes that entries at this speed may possibly be avoided through use, for example, of other than atmospheric braking schemes, though probably with some weight penalty, and that actual g-forces on an astronaut may be tolerable beyond the normally used 10-g level. He expects that extended-duration *Apollo* missions will yield new data on this—and also indicate what kind of g-levels can be tolerated by pilots who are returning after a 420-day manned Mars mission.

Wingrove also points out that entering at extreme velocities also will make major new demands upon the state-of-the-art in mid-course guidance systems needed to guide a spacecraft to a safe re-entry corridor "which gets pretty thin, on the order of 10 miles or less," at these speeds. Errors in the mid-course system combined with atmospheric uncertainties are major factors affecting usable corridor depth.

In addition to the entry speeds and the maximum acceleration tolerances, the vehicle L/D ratio and the type of vehicle control all contributed to determination of corridor depth and provide some trade-offs for spacecraft designers. Wingrove says that some of the possibilities for obtaining a 10-mi. corridor at Earth re-entry speeds of 70,000 ft. include: use of roll modulation with an L/D=1 vehicle and a maximum 10-g acceleration level; roll modulation with an L/D=0.5 vehicle and a 14-g maximum; pitch modulation (where the acceleration vector changes with respect to the pilot) with an L/D=0.5 and a 10-g maximum; and area modulation (where the surface area normal to the force vector is regulated to reduce the g-load) with an L/D=0.5 and 10-g maximum.

Wingrove also concludes that with automatic control used for the capture maneuver, there is no degradation in the usable corridor depth for ± 10% uncertainties in density gradients and for vertical velocity measurements errors under about ± 200 ft./sec.

● **Unmanned designs in hand**—Two scientists from General Electric Co.'s Re-entry Systems Dept. told the AIAA audience that "entry technology required for unmanned planetary exploration vehicles is well in hand and design needs are well within the present state of the art."

Studies by GE, some of which were funded by NASA, showed that a rather broad family of blunted sphere-cones could be considered for lander vehicles, and that a near-optimum Mars entry vehicle might have a bluntness ratio near 0.6 and a half-cone angle of about 50 degs. Weight and cost factors in selection of structural materials for Mars vehicles led GE to aluminum and magnesium in a honeycomb-sandwich-type of construction. For entry into a higher-surface-temperature Venus atmosphere, studies showed the need for materials such as titanium, stainless steel, or beryllium.

Due to the relatively low-density Martian atmosphere, the requirements for soft-landing retardation systems are increased to represent about 20% of the total entry vehicle weight, according to GE. By use of high-drag-to-weight-ratio parachutes and crushable aluminum honeycomb impact attenuation



New dual-micrometer alignment telescope

Kollmorgen Model K122 provides micrometer readings of two-plane displacements as small as 0.001-inch at distances up to 100 feet (0.0005-inch at closer ranges).

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systems, and other optimization of the vehicle, GE scientists say that about 50% of the total weight can be devoted to the gross payload, and that the scientific payload can range from 5-25% of total weight, depending mostly upon the size of the lander.

For example, using the *Atlas-Centaur*, a 545-lb. *Mariner* lander would have a 35-lb. scientific payload, while a 1,270-lb. *Voyager* aboard a *Titan III-C* or *Saturn IB* would have a 160-lb. scientific package. A 17,200-lb. *"Beagle"* class lander aboard a *Saturn V* would have a 5,000-lb. scientific payload capability.

● **OART needs**—While entry technology may be moving forward, NASA Associate Administrator Dr. Raymond L. Bisplinghoff told the gathering here that much remains to be done in the fields of energy conversion, materials, measurement and control, and communications for full exploitation of interplanetary flight programs.

For deep-space penetration with large payloads and for manned Mars missions at any launch opportunity, Bisplinghoff said, progress in solid-core graphite reactor technology should lead to development of a range of lightweight reactors able to provide 1,000-5,000 megawatts of power for nuclear engines. A nuclear third-stage aboard *Saturn V* would allow exploration of the environment close to the Sun at large distances from the plane of the ecliptic, and would also allow large payloads in orbit around Venus, Mars, and Jupiter. Bisplinghoff said this could be augmented by a fourth "kick" stage or possibly an electrical propulsion system for additional velocity increments beyond the Earth's gravitational field.

Bisplinghoff called for new materials technology and containment processes for nuclear engines. In concept, he said, we may expect to achieve gas temperatures on the order of 5,000-6,000°F with graphite or tungsten fuel elements operating for short periods of time. He said that new containment concepts could perhaps transcend some materials limitations.

For example, he said, if gaseous containment of the fission process could be devised this could permit nuclear propellant temperatures of 100,000°R. Thermonuclear rockets, he added, are also conceptually possible in which temperatures of 100 million°K. are contained by electromagnetic fields. The problems of containing fission and fusion processes in these ways are not yet solved, he stressed, but the ultimate promise merits major effort.

Discussing large quantities of electric power for space, Bisplinghoff said future use of MHD energy converters with higher-temperature reactors offered higher efficiencies, and their use with gas containment of the fission process is "very attractive." Bisplinghoff even looked toward the use of fusion as an electrical producer in space, though he emphasized that the problems of starting and containing the Deuterium process are so formidable that use is still decades away.

In calling for major improvements in precise pointing capabilities and sensor systems, the NASA scientist said that current accuracies of 0.1-1 deg would be compounded to provide about 10^{-3} deg pointing accuracies for advanced solar observatories and 10^{-5} degs for laser and long-range astronomical observatory systems. He also said that current 1-2-deg-resolution horizon scanners would have to experience a major improvement to 0.001 deg sensitivities in the future. He said techniques other than IR sensing, such as visible airglow detection, ultraviolet and RF radiation systems are possibilities.

In the communications area, Bisplinghoff said bit rates over interplanetary distances would have to undergo major increases, particularly to reach the 10-100 million bits/sec needed for high-quality TV.

The *Mariner* probe has an early capability equal to about 1 bit each 5 secs from Mars. This possibly can be improved to about 2,000-5,000 bps by the early 1970's. This is still too slow for TV, he noted. There is some doubt that microwave techniques could ever be expanded to those rates, he said, and he indicated that optical systems may be necessary.

● **Parasail/landing rocket**—While the parachute landing recovery system being developed for *Gemini* and *Apollo* still does not vary greatly in concept or capabilities from that used in Project *Mercury*, a team of NASA Manned Spacecraft Center scientists reported on new development programs at Houston aimed at exploring improved systems.

A parasail/landing rocket development program now in progress is billed as "the most advanced landing system program" undertaken by MSC thus far and is slated for completion in 1965. This is basically a controllable gliding chute with a low-thrust landing rocket which serves as an impact attenuator. In wind-tunnel and aerial-drop tests, NASA says, unstiffened canopies have exhibited L/D ratios as high as 2.1 in some configurations which, combined with a landing rocket system, could provide a spacecraft landing capability in land or water with enough maneuverability to avoid local obstacles. As of now, there are no plans to land either *Gemini* or *Apollo* on land. And, as one scientist points out, there must be a requirement for the system to come down on land before a decision is made to incorporate the added weight of such a landing system.

In addition to the parasail/landing rocket project, NASA is known to be interested in an Air Force clustered-parachute concept which reportedly provides an L/D=2 and would allow operation in high wind velocities. NASA has also expressed interest in a rotor recovery system, developed by Kaman Aircraft Corp., which was described for the AIAA audience. ■

'Grating Lobe' Method Slims Arrays

PHASED-ARRAY radar elements can be reduced in some applications by up to 98.5% and still provide high resolution, Martin Co. engineers report.

For passive or active ground or aircraft use with relatively large-aperture arrays, Warren A. Birge of the Orlando Division's Research Center proposes use of a grating-lobe (multi-element inferferometer) array. He claims that a 10-12 element "thinned array" installed beneath an aircraft can produce a resolution equivalent to that achieved by a 650-element array of the same overall size. Aerodynamic drag and electrical losses (at K band) would be minimal.

In the grating-lobe technique, dissimilar transmitting and receiving apertures are employed. The length and location of the transmitting horns, relative to the inter-element spacing of the receiving horns, are critical. In operation, the open antenna areas are synthesized electronically, producing a readout pattern equivalent to that provided by a more conventional "filled-in" array.

Birge said the pattern for a flight-type system in the acquisition mode would sweep 30-33 degrees on each side of the flight path at a 25 cycle/sec. frame rate and an angular resolution of 1.2 degrees.

After acquisition and target identification, Birge said, a high-resolution mode could be initiated. At K_u band, resolution would be of the order of 2 milliradians; at K_a band, about 1 mrad. These resolutions, he pointed out, are 10 times better than those obtained by any existing forward-looking radars.

Ranges of more than 10 mi. are practical, the engineer disclosed.

ITT Gilfillan radar aboard the USS Kearsarge.



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ITT Gilfillan is the company that 10 years ago introduced 4-in-1 radar (search, precision approach, height finder, taxi, all in one system) to the world.

The U.S. Army, the Navy, the Marines and the Air Force, as well as a dozen foreign nations, have bought and are still buying its radar systems.

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New Activities

The General Electric Co. and the University of Pennsylvania have formed a working relationship called Associates for Astronomical Research (AFAR), which aims at bringing together the basic research skills of the university with the technical skills of industry for the purpose of conducting a long-range endeavor in the field of astronomy. Much of the work will be centered at a new observatory being built in New Zealand by AFAR and the University of Canterbury. . . . *Honeywell, Inc.'s military products facility in Boston has been expanded beyond the electro-optics field to include research and development in radar and other applications of high-frequency radiative energy. The facility will be renamed the Honeywell Radiation Center to more properly reflect the expanded activities.* . . . C-E-I-R, Inc., Arlington, Va., research and data processing firm, has formed a new Statistical Sciences Div. to offer complete services in mathematical-statistical analysis to business and government through a single corporate unit. . . . *I. D. Black & Associates has been formed as a management consultant firm in Washington, D.C. The organization is to provide services in the fields of technical marketing intelligence and analysis, research, development and advanced planning. The firm's technical staff includes engineering personnel specializing in missile and aviation systems, aerospace and electronics, with emphasis on surveillance, reconnaissance and intelligence systems.*

Mergers and Acquisitions

Dynamics Corp. of America, New York City, has acquired the Massa Div. of Cohu Electronics, Inc., San Diego, Calif. The Massa Div. plant, located in Hingham, Mass., is a specialized developer and producer of anti-submarine warfare and oceanographic equipment. Purchase price was said to have been in "excess of $2 million." . . . *The Marquardt Corp., Van Nuys, Calif., has announced plans to acquire the assets of Automation Laboratories, Inc., Mineola, N.Y. AL develops and produces television pickup and display equipment, visual scanning devices, precision angle measuring equipment and radar simulation equipment. The firm, which is Marquardt's first East Coast acquisition, will be operated as a wholly owned subsidiary.* . . . Walter Kidde & Co. and Associated Testing Laboratories, Inc., boards of directors have approved a plan for the acquisition of AT by Kidde. Pending approval by stockholders, the acquisition would involve a stock trade of all AT common stock at a rate of 10 shares of AT per 3.5 shares of Kidde. AT performs environmental and reliability testing for industry. . . . *Regency Electronics, Inc., Indianapolis, Ind., has acquired 95% of the stock of Metrotek Electronics, Inc., Raleigh, N.C. Basis of the acquisition was one share of Regency stock for 125 of Metrotek. Metrotek is to operate as a separate subsidiary of Regency and retain its name and product line consisting predominately of citizen's band transceiver equipment.* . . . Lear Siegler, Inc., Santa Monica, Calif., has purchased for an undisclosed amount of cash all assets of the Air Valves Co., Inc., of Warren, Mich. To be known as the Air Valves Div. of Lear Siegler's Power Equipment Div., the acquisition will add to LS's capabilities in the design, manufacture and marketing of compact, lightweight air valves and pneumatic safety controls. . . . *Vacuum Industries, Inc., Sommerville, Mass., producers of high vacuum equipment and instruments, has acquired for cash the Mt. Vernon Research Co., of Alexandria, Va.*

Missile/Space Facilities

Glenair, Inc., Glendale, Calif., designer and manufacturer of connector and cable accessories and special connector assemblies for the missile/space, electrical and instrumentation industries, has opened a new 15,000-sq.-ft. plant, tripling the size of its previous facilities. . . . *Lockheed-California Co., Burbank, has begun operations of a test facility designed to develop advanced fuel systems for future spacecraft and spaceplanes. The facility consists of a 1,730-sq.-ft. air-conditioned control blockhouse with cells for both structural and operating systems experiments at cryogenic temperatures and a large outside test pad. Systems tests will involve propellant tanks, valves, flow lines, pumps, insulation pressure control and safety devices.* . . . Tamar Electronics Industries, Inc., has announced plans to establish an industrial complex in Gardena, Calif., for research, development and manufacturing of electronic systems and components. The new facility will be part of a reorientation of the Stoddart Aircraft Radio Co., a Tamar subsidiary.

Government Research Scrutinized

The President's Science Advisory Committee is studying the question of whether the functions of some government research laboratories might not be met more economically by private industry. The Commission is concerned over the apparent lack of overall governmental planning and control of the labs, the exact number of which the Committee has been unable to determine. Best current estimate is 150 labs spending $500 million a year. Among questions the Committee hopes to answer are: How productive are government labs in comparison to those of industry? Are some government labs being bypassed by changing technology? Is lack of adequate control allowing government labs to move from their original missions into areas for which they are not properly qualified? Impetus for the study was a recent National Academy of Sciences report calling for better use of engineering and scientific talent, both in and out of government.

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$7,400,000—**GT&E Corp.,** Sylvania Electric Products, Inc., New York City, for production and delivery of advanced airborne data-processing equipment for incorporation into larger electronic systems.

$2,800,000—**TRW Space Technology Laboratories,** Redondo Beach, Calif., for work on AF space programs.

$2,375,000—**International Telephone & Telegraph Corp.,** New York City, for work on test-range communications at various locations.

$2,350,000—**Litton Industries, Inc.,** Woodland Hills, Calif., to contract for equipment to overhaul and test inertial navigation systems.

$1,800,000—**Lear Siegler, Inc., Instrument Div.,** Grand Rapids, Mich., to provide two-axis flight director indicators.

$1,300,000—**General Electric Co.,** Philadelphia, for the development and testing of unspecified space vehicles.

$1,200,000—**Collins Radio Co.,** Dallas, for technical services involving voice and data communication equipment and flight control equipment.

$1,001,044—**Lockheed Missiles & Space Co.,** Sunnyvale, Calif., for repairs to *Agena D* rocket booster.

$225,500—**North American Aviation, Inc.,** Rocketdyne Div., Canoga Park, Calif., for research in high-energy oxidizers.

$107,500—**Hughes Aircraft Co.,** Culver City, Calif., for three-month pre-phase-1 study of the autonomous navigation definition for the *Manned Orbiting Laboratory*.

$47,760—**D. B. Milliken Co.,** Arcadia, Calif., for high-speed 16-mm motion-picture cameras.

$44,000—**United Aircraft Corp.,** Hamilton Standard Div., Windsor Locks, Conn., for three-month pre-phase-1 study of the environmental control and life support subsystems for *Manned Orbiting Laboratory*.

ARMY

$3,152,975—**Bendix Corp.,** Teterboro, N.J., for R&D and other work on *Pershing* missile.

$1,977,933—**Belock Instrument Corp.,** College Point, N.Y., for engineering services to support the *Hawk* simulator-trainer.

$262,150—**Western Electric Co.,** New York City, for *Nike X* DR and TTR receiving components.

$25,658—**Sperry Rand Corp.,** Salt Lake City, Utah, for repair parts for *Sergeant* missile.

Electro-Mechanical Research, Inc., Sarasota, Fla., for study and evaluation of FM telemetry at White Sands Missile Range (amount undisclosed).

NAVY

$9,573,525—**Lockheed Aircraft Corp.,** Sunnyvale, Calif., for work on the *Polaris* missile program.

$2,292,412—**Motorola, Inc.,** Scottsdale, Ariz., for target-detecting devices for use with *Talos* missiles.

$1,507,750—**Lockheed Aircraft Corp.,** Sunnyvale, Calif., to make components for *Polaris* missiles.

$822,896—**Vitro Corp.,** Vitro Laboratories Div., Silver Spring, Md., contract extension for system engineering work on Navy ships being armed with the *Terrier, Tartar* and *Talos* missile systems.

$66,427—**Atlantic Research Corp.,** Alexandria, Va., for contract modification for a research program to study the physical properties of solid propellants.

$22,018—**Goodyear Aerospace Corp.,** Akron, Ohio, for production of *Subroc* missiles.

Informatics, Inc., Sherman Oaks, Calif., for analytical studies and computer programming associated with the Fleet Automatic Vectoring System to be installed at Pacific Missile Range, Point Mugu (amount undisclosed).

NASA

$2,600,000—**Hayes International Corp.,** Birmingham, Ala., for high-pressure gas distribution system for NASA launch complexes 34 and 37 at Cape Kennedy and complex 39, Merritt Island Launch Area.

$442,393—**Lockheed Georgia Co.,** Marietta, Ga., for modification and refurbishment of *Saturn IB* arm assemblies, hydraulic control panels and assemblies to complete the swing arm systems.

$261,665—**Space Craft, Inc.,** Huntsville, Ala., for development, fabrication and delivery of two prototypes and four production model radar altimeters.

$260,000—**Fairchild Hiller Corp.,** Space Systems Div., Rockville, Md., to design and fabricate an "Advanced Solar Array" for the advanced *Nimbus* weather satellite.

$200,000—**Cook Electric Co.,** Morton Grove, Ill., for 10 biomedical recorders for use by *Gemini* astronauts.

$170,000—**Chrysler Corp., Space Div.,** New Orleans, La., for a seven-month study to establish a method to increase the payload capability of the *Saturn IB* space vehicle.

$74,752—**University of Southern Calif.,** Los Angeles, for investigation to determine the effects of long-term bed rest on g-tolerance and on psychomotor performance.

$74,452—**Northeastern University,** Boston, for R&D services on human decision processes in simulated advanced aerospace surveillance system.

$71,106—**University of Texas,** Austin, for development of methods for predicting the behavior of a manned spacecraft landing on soil.

$70,330—**Goerz Optical Co.,** Pittsburgh, for lunar camera design study.

Douglas Aircraft Co., Inc., Missile & Space Systems Div., Santa Monica, Calif., to conduct a six-month analytical study of lunar orbit missions for an *IMP*-type satellite which can be launched in 1966 with the new *Improved Delta* space booster (amount undisclosed).

Fairchild Hiller Corp., Space Systems Div., Rockville, Md., to design and develop a thermionic diode controlled power system to investigate and evaluate nuclear powered electrical systems to be used for prolonged space flights (amount undisclosed).

Fairchild Hiller Corp., Space Systems Div., Rockville, Md., for R&D of a "Deployable Solar Array."

INDUSTRY

$9,000,000—**Radio Corp. of America,** New York City, from **Grumman Aircraft Engineering Corp.,** Bethpage, N.Y., for a major portion of the stabilization and control system in the Lunar Excursion Module.

$4,500,000—**Radio Corp. of America,** Camden, N.J., from **The Boeing Co.,** Seattle, for work in connection with the Air Force *Minuteman* ICBM program.

$2,000,000—**Beckman Instruments Inc.,** Fullerton, Calif., from **Aerojet-General Corp., Aetron Div.,** Covina, Calif., for data acquisition and processing systems to be used in testing the *Saturn V* booster.

$975,000—**Radiation, Inc.,** Melbourne, Fla., from **The Boeing Co.,** Seattle, for work on the *Lunar Orbiter* program.

$850,000—**Talley Industries, Inc.,** Mesa, Ariz., from **The Boeing Co.,** Seattle, to perform modification work on equipment which will be installed at *Minuteman* field locations.

$600,000—**Itek Corp.,** Lexington, Mass., from **Canadair, Ltd.,** Canada, for production of fourteen small, lightweight aerial camera systems, and associated equipment.

$550,000—**GT&E, Sylvania Electric Products, Inc.,** New York City, from **North American Aviation, Columbus Div.,** Columbus, Ohio, for fabrication of 30-ft.-dia. transportable antenna systems.

$250,000—**Electronic Communications Inc.,** St. Petersburg, Fla., from **The Boeing Co.,** Seattle, for radio equipment for the *Minuteman* improvement programs.

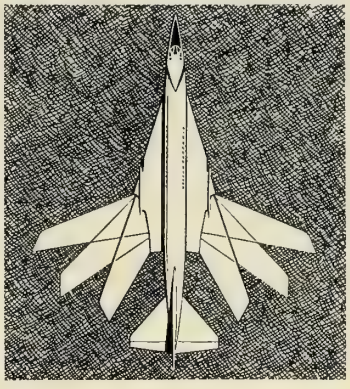
$200,000—**Cook Electric Co., Data-stor Div.,** Skokie, Ill., from the **Martin Co.,** Orlando, Fla., for Model 56 punched tape readers used in the ground computer of the U.S. Army's *Pershing* missile system.

Philco Corp., Western Development Laboratories Div., Palo Alto, Calif., from **California Institute of Technology, Jet Propulsion Laboratory,** Pasadena, for a study to develop designs for spacecraft that would travel to comets or to close-approach asteroids (amount undisclosed).

ENGINEERS:

Design and Development openings at Boeing

Boeing, world leader in advanced swept-wing, multi-jet aircraft, is today pioneering evolutionary advances in both civilian and military aircraft fields. These programs have created outstanding openings in the Pacific Northwest with Boeing's Airplane Division for graduate engineers at all experience levels in the fields listed below. Minimum educational requirement is a B.S. degree in an engineering discipline, except where noted.



DESIGN

Structural—Duties include the determination of aircraft structural requirements, preliminary sketches and preparation of final layout drawings and investigation.

Hydraulic—Duties include design of hydraulic systems and hydraulically actuated mechanisms, including brake-flaps, spoilers, landing gear doors, landing gear and nose wheel mechanisms.

Air Conditioning & Pneumatic Systems—Positions include the design of air conditioning and pneumatic systems, cabin heating and ventilation, cabin pressurization, electronic equipment cooling, and temperature control of aircraft surfaces.

Aircraft Control—Duties involve design of controls including ailerons, elevators, rudder, trim tabs and engine controls.

Power Plant—Assignments involve the design of engine installations, engine accessories, strut and engine supports, engine nacelles, and thrust reversers / sound suppressors.

Fuel Systems—Positions include design of fuel systems, fuel and tank ventilation systems, water injection and tank purging systems.

DEVELOPMENT

Structural Dynamics—Duties involve analysis and experiments in aeroelastic fields of flutter and dynamic loads. B.S. or advanced degree required in applied mechanics with significant aerodynamic and structures background related to high-speed aircraft. Should be familiar with latest theories and techniques for analysis and test.

Stability and Control—Openings require strong background in airplane flight control system design and analysis, and stability and control characteristics, plus knowledge of computers, servomechanism design and development and testing of airplane configurations. Master's degree or equivalent.

Flight Control Systems—Positions involve establishing dynamic design criteria and specifications for flight control systems, subsystems and components; selection of most suitable control system components, and guidance of control system procurement and flight test. Requires B.S. or M.S. in engineering, mathematics or physics with applicable experience.

Metallurgy and Mechanical Engineering—Assignments entail alloy selection and application, development and improvement of processes, preparation of specifications, laboratory experiments, technical consultation, and service failure analysis. Requirements, in addition to experience in aircraft technology or a related field, include familiarity with the electron microprobe and microscope and standard metallurgical equipment.

Chemical Engineering—Openings require experience in lubrication materials and concepts; elastomeric, inorganic finish, and organic polymeric materials, and structural adhesive bonding, plus a basic knowledge of materials behavior. Work involves evaluation, analysis and investigation of all materials characteristics, including mechanical, electrical, chemical and surface.

Propulsion—Responsibilities include research and development, primarily V / STOL oriented, in the fields of subsonic and supersonic inlets, thrusting ejectors and engine fan thrust vectoring; engine cycle analysis, engine / airplane optimization studies for subsonic and supersonic propulsion systems, and VTOL propulsion technology.

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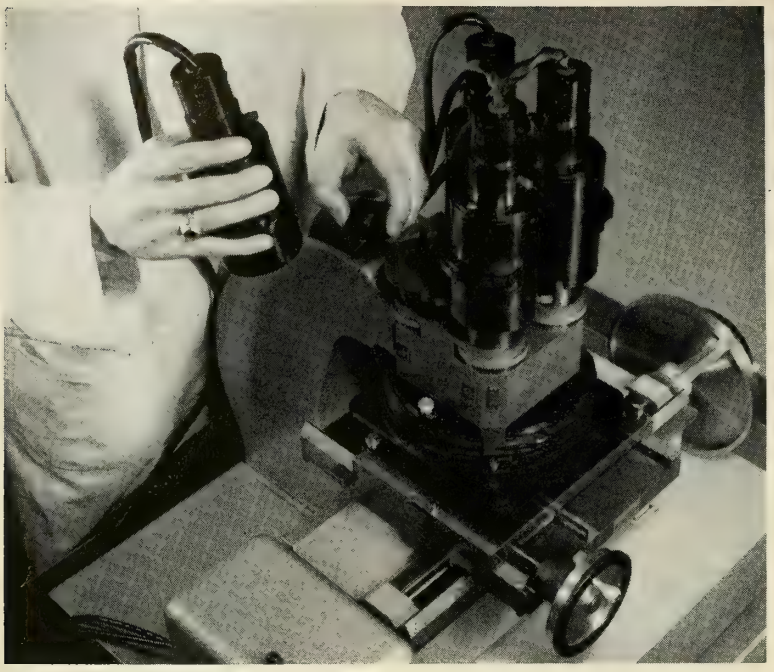
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New Product of the Week: Photo Reducer/Printer

An instrument for more rapid and less expensive automatic production of original glass plate photomasks, used in the manufacture of semiconductor integrated circuits, has been developed by David W. Mann Co., a division of Geophysics Corp. of America.

The "Photorepeater" is equipped with four barrel-like microreduction printers each capable of simultaneously completing up to 150 programmed exposures in less than 30 secs. on a continuously moving glass plate (2 x 2 x 0.6 in.). The four printers are able to complete a total of eight original masks per hour, the firm says, each plate containing 30 to 50 rows of complex patterns with elements guaranteed to be accurate to within ±0.00005 in.

A punch-tape control system provides automatic programming of the number of exposures to be accomplished in each row. It also permits inclusion or exclusion of an exposure at any desired point.

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Bellows Sealed Valve

Fox Valve Development Co., Inc., has introduced a series of bellows sealed throttling and shut-off valves, designed for high-temperature, high-pressure service.

The valves are available in stainless steel, 9% Cr —1% Mo, stellites and refractory metals. They feature a thermally isolated bellows section, said to contribute to long bellows life. The all-metal construction has led to utilization of the valves in cryogenic service where no external leakage is permitted, the firm says.

One variation for sampling purposes in test loops has a self-purging bellows section. This allows dynamic sampling of a flow process without sample contamination by residue in the bellows cavity from previous samples.

The units are available with manual or pneumatic operators. Line sizes range from 0.25 to 16 in.

Circle No. 152 on Subscriber Service Card

Digital Tachometer

A portable digital tachometer for measurement and display of shaft speed (RPM) and surface speed (FPM) without other equipment has been announced by Avtron Manufacturing, Inc.

The Model T572 is composed of a hand-held pulse generator and an electronic counter. No switching is required when changing from RPM to FPM because the same count time is used for both. Readout of speed is displayed for a time range of 0.8 to approximately 10 secs.

The unit can operate from its own batteries or a 115v input.

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Line Impedance Bridge

A line impedance bridge for measuring RF line impedance and phase angle without direct connection to a power line has been announced by Solar Electronics Co.

In the Model 6363-1, two current transformer probes couple to unknown impedance units, providing measurement magnitudes from 1 to 1,000 ohms and phase angles of ±180 degrees over a frequency range of 15 kc to 25 mc. Power line currents up to 100 amps have negligible effect on measurements. Impedance measurements are accurate to ±12%, phase angles to ±10%.

Circle No. 154 on Subscriber Service Card

Shock Test Machine

L.A.B. Corp. is marketing a rapid sequence shock machine designed for production testing of semiconductors.

The Model SDF-4.5-96-4 has a 4-lb. test load capacity and can deliver 3,000 g's, 0.7 ms shocks from a 96-in. drop distance at a rate of 12/min. and 1,500 g's, 1 ms shocks from 60 in. at a rate of 15/min.

The carriage is raised to a preselected drop height by a chain hoist where the rebound brake is automatically opened and the carriage allowed to fall. On impact, the brake actuates and prevents secondary shocks. Interchangeable elastomer shock pads are furnished to produce shock pulses at different durations.

Circle No. 155 on Subscriber Service Card

Diode Laser Pulse Generator

The Model DLP-2 pulse generator, designed especially for use with gallium arsenide diode laser systems, is being marketed by Maser Optics, Inc.

The unit has a rated peak output of 300 amperes. Nominal pulse width is 10 nanosec. and rise time is 1 nanosec. It can be internally or externally triggered or operated in a single-shot manner. With internal triggering, pulse repetition rate can be continuously varied from 10 to 200 pulses per second. With external timing, rate varies from zero to 200 pps. The device permits room temperature operation of the diode laser.

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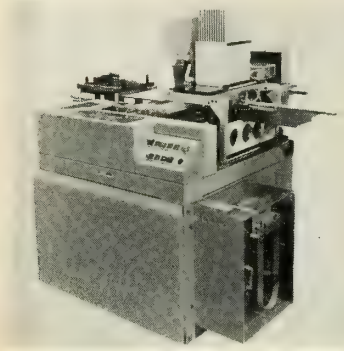
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Component Insertion Unit

IBM Industrial Products Div. has available a high-speed production machine for inserting components into printed circuit cards.

The ME 501 provides random selection of up to 24 different ¼-watt resistors for insertion into printed circuit cards at a maximum rate of 4,500 insertions per hour. The machine consists of a panel feeder, a transport system, a punched tape reader and a hopper assembly.



An optional PREP (preparation) machine is utilized to cut the axial leads to a pre-selected length and load the components into the magazine.

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Helium-Neon Laser

A continuous wave helium-neon laser, designed for instrument, system and experimental applications, is being marketed by Spectra-Physics, Inc. The Model 131 utilizes dc excitation to provide simpler operation and to eliminate interference normally encountered with RF excitation sources.

Output of the laser is 6,328 A, with optional outputs at 11,523 or 33,912 A. CW power in a diffraction-limited, uniphase wavefront exceeds 0.5 milliwatts in the hemispherical resonator configuration. More than one milliwatt is obtainable in a multiphase wavefront on the confocal resonator configuration. Beam diameter is 1 mm at the exit aperture; beam divergence is less than 0.7 milliradians when using the hemispherical resonator.

Circle No. 158 on Subscriber Service Card

Power Contactor

The 3 PST/NO 20-amp power contactor, capable of handling 3-phase ac ratings, is being marketed by Leach Corp.

The unit is available in three models: 28v dc; 115v ac, 60 cps; and 115v ac, 400 cps. It meets MIL-R-6106C specifications and is capable of operation in a temperature range of −70° to 120°C. It can withstand shocks of 25 g's, vibration of 10 g's to 1,500 cps and acceleration to 15 g's. The device measures 2.4 × 2.5 × 1.5 in. and weighs 0.6 lb.

Circle No. 159 on Subscriber Service Card

Semiconductor Test Set

The Model 430 semiconductor test set, capable of completing 20 tests in one second, is being marketed by Aerotronic Associates, Inc. Accuracy is better than 1% on a "go, no-go" basis.

The system is designed to test encapsulated diode matrixes, but the use of solid-state logic and operational amplifier techniques permit the basic design to test most semiconductors, the firm says.

It utilizes a "self check" method to assist in maintenance and employs special cards containing resistors to program the test parameters. The set is capable of reading out the exact value of any one parameter during normal operation without interferring with the operation of the system.

Circle No. 160 on Subscriber Service Card

Integrating & Time Base Unit

An integrating and time base unit, which permits standard data analyzers to be used as multi-scaler or signal averaging computers, has been announced by Nuclear Data, Inc.

The ND-180ITB unit provides capabilities of multichannel scaling for events as a function of time or velocity, and signal averaging for the enhancement of signal-to-noise ratios.



Circle No. 161 on Subscriber Service Card

Temperature Chamber

A portable temperature chamber designed especially for vibration testing and equipped with a lift ring for connection to most shakers is available from Conrad, Inc.

The Model PBV-6 is cylindrical with an open bottom for connection. Test area is nominally 24 × 24 in., but may be decreased slightly when adapters are used. Temperature range is −100° to 300°F with CO_2. Other models are available with a −300°F range using LN_2. An optional cover for the bottom of the chamber allows its use as a portable temperature test facility independent of vibration.

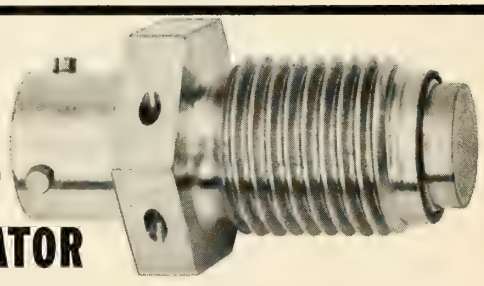
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Audio Limiter

Kahn Research Laboratories, Inc., has developed the Model LIM-63-1A limiter amplifier. The device utilizes two compactrons and one octal tube and meets FAA R543-D specifications.

It covers a range of 300 to 3,000 cycles. Input and output impedances are 600 ohms, with a 25-ohm microphone input provided. Precision step attenuators on both input and output circuits are included in the system.

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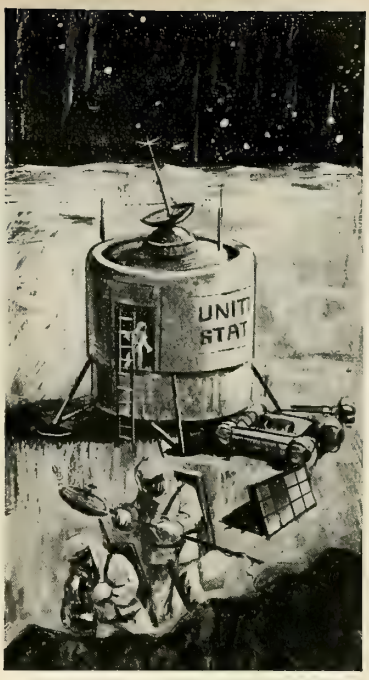
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4th annual NASA issue

november 30, 1964

MISSILES AND ROCKETS, the weekly of Space Systems Engineering, will publish its fourth annual NASA Issue on November 30, 1964.

This annual issue, now accepted as the authoritative publication on the nation's space agency, will examine future procurement plans of the National Aeronautics and Space Administration and three organizations allied with it in exploring the peaceful uses of space, Communication Satellite Corporation, Atomic Energy Commission and the U.S. Weather Bureau.

With major procurement for the Apollo manned lunar landing program now behind it, NASA is deep in the planning for new projects to expand man's knowledge of space, including such post-Apollo missions as the Lunar Logistic Supply System, Manned Orbital Research Laboratory, Extended Apollo, Project Voyager and Manned and Unmanned Planetary Probes. ComSat Corp., AEC and the Weather Bureau are drawing up plans for their growing participation in the peaceful use of space.

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These positions are directly connected with a challenging research program constituting one of the key activities in the new Research Center now under construction at the Lockheed-Georgia Company, Marietta, Georgia.

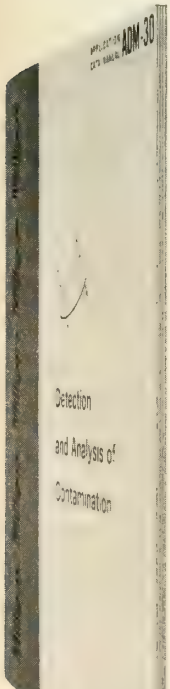
Send resume, in confidence, to: Dr. C. H. von Kenschitzki, Associate Director of Research, Lockheed-Georgia Company, 834 West Peachtree Street, Atlanta, Georgia 30308, Dept. QQ-77.

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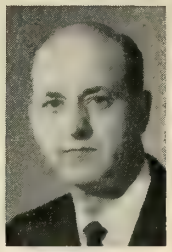
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names in the news


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Charles L. Ill: Elected senior vice president of Page Communications Engineers, Washington, D.C.

Ralph E. Grimm: Named president of Communication Electronics, Inc., Rockville, Md. He is one of the original founders of CEI and has been serving as executive vice president of the company.

Richard J. Flynn: Named executive vice president of Ling-Temco-Vought Continental Electronics Div., Dallas.

George P. Baker: Elected a director of the Lockheed Aircraft Corp., Burbank, Calif. He is also dean of the Graduate School of Business Administration at Harvard University.

Roy H. Beaton: Appointed general manager of the General Electric Co.'s *Apollo* Support Dept., Daytona Beach, Fla.

Rocket Power, Inc., a subsidiary of the Maremont Corp., announced the following promotions and additions to the company's Mesa, Ariz., facility: **H. E. Roy,** chief engineer, propellant development; **W. E. Bullion,** chief engineer, ballistic devices; **V. D. Williams,** chief engineer, flight vehicles; **D. R. West,** manager, test department; **L. E. Cates,** manager, contracts administration; **D. L. Byrd,** program management office.

Harold E. Tately: Appointed manager of market research for the Advanced Product Planning Operation of the General Electronic Components Div., Schenectady, N.Y.

Dr. Van Zandt Williams: Chosen as president-elect of the Optical Society of America at its 49th annual meeting. He will assume office Jan. 1, and preside for one year. He is with Perkin-Elmer Corp., Norwalk, Conn.

William Meng Duke: Named president of Whittaker Corp., Los Angeles. He was formerly with ITT Corp. and has been associated prominently with such programs as *Terrier* and *Lacrosse, Titan, Minuteman, Explorer VI, Pioneer V, Thor/Able, Atlas/Able,* and *OGO.*

Fred R. Raach: To be vice president and general manager, Data Processing Div., Univac Div. of Sperry Rand Corp., New York City. Also promoted were **Robert E. McDonald,** vice president and general manager of the Univac Defense Computer Systems Div.; and **David H. Baker,** vice president and general manager of Univac's International Div.

Joseph G. Lundholm: Appointed director of advanced research and technology for Space Systems Div. of Fairchild Hiller Corp., Washington, D.C.

J. N. Graham, Jr.: Appointed vice president of Mesa Scientific Corp., Inglewood, Calif. This action follows the merger of Mesa with Systems Programming Corp., of which he was vice president and general manager.

Capt. Frank M. Sanger, Jr., USN: To be technical director for the Navy's Antisubmarine Warfare Systems Project. He will be responsible for the technical aspects of all systems and equipment whose production is managed by the ASWS Project office, Navy Bureau of Material.

Charles H. Weaver: Elected to the executive committee and to the board of trustees of the National Security Industrial Assn. He is group vice president, atomic, defense and space group of Westinghouse Electric Corp., Pittsburgh.

Bernard R. Garrett: Appointed director of engineering of Instrument Systems Corp., Huntington, N.Y.

Barney Hayden: Chosen executive vice president of Greer Hydraulics, Inc., Los Angeles. He is also on the board of directors.

Charles H. Willis: Appointed director of the Ocean Engineering Div., Ocean Space Services, Inc., Annapolis, Md.

Robert J. Fuchiek: Appointed director of engineering for Whittaker Corp.'s Electronics Div., North Hollywood, Calif. He will be responsible for the engineering of data instruments, and other products.

Robert Bottorff: Named to the board of directors of Scantlin Electronics Inc., Los Angeles. He is treasurer of Dow Jones & Co., Inc. and publisher of the *Wall Street Journal, National Observer, Barron's* and the Dow Jones *News Service.* **Bradford Mills,** partner in New York Securities Co., was also named to the board.



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OCTOBER

Symposium on Unconventional Inertial Sensors, sponsored by the Navy, Republic Aviation Corp., and other government agencies, Long Island Graduate Center of the Polytechnic Institute of Brooklyn, Farmingdale, N.Y., Oct. 19-20.

Annual Meeting of the Human Factors Society, Mayflower Hotel, Washington, D.C., Oct. 19-21.

National Electronics Conference, sponsored by the IEEE, McCormick Place, Chicago, Oct. 19-21.

Engineering Aspects of Space Medicine, a short course given by The George Washington University, Washington, D.C., Oct. 19-30.

Eleventh Annual Air Force Science & Engineering Symposium sponsored by the Air Force Systems Command and the Office of Aerospace Research, Aerospace Medical Division, Brooks AFB, Tex., Oct. 20-22.

East Coast Conference on Aerospace and Navigational Electronics, sponsored by the IEEE, Baltimore, Oct. 21-23.

Conference on Spectroscopy, Instrumentation and Chemistry, sponsored by the Northern California Society for Spectroscopy and the American Chemical Society, Jack Tar Hotel, San Francisco, Oct. 21-23.

17th Annual Gaseous Electronics Conference, Atlantic City, N.J., Oct. 21-24.

20th Annual National Conference on Fluid Power, sponsored by Illinois Institute of Technology, Sherman House, Chicago, Oct. 22-23.

Western States Section/The Combustion Institute Fall Meeting, University of Utah, Salt Lake City, Oct. 26-27.

Joint Meeting of AIAA and the Canadian Aeronautics and Space Institute, Ottawa, Ontario, Canada, Oct. 26-27.

10th Conference on Welded Electronic Packaging, sponsored by the Society of Automotive Engineers, Belmont Plaza Hotel, New York City, Oct. 27-28.

11th Symposium on Nuclear Science, sponsored by the IEEE and Air Force Office of Scientific Research, Philadelphia, Oct. 27-29.

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The Gauntlet

THE FLIGHT of the *Voskhod* came like a sharp and well-deserved slap in the face. The banner headline on page one of the *Los Angeles Times* said it as well as any: "Russ Jeer at Us."

The Russians might well jeer at us. At the outset of his Administration, the late President Kennedy picked the first manned lunar landing as a foremost national goal. After careful study of the lagging U.S. space program, it had been determined that this was the first major space objective to which this nation had a good chance of beating the Russians.

The President, determined to wring the utmost in excellence from U.S. science and technology, issued the challenge publicly before the Congress in May, 1961.

Despite every indication that the Soviets indeed had accepted our selection of the Moon for a race between the two nations, the *Apollo* priority soon began to sag.

President Kennedy himself, in one of the most ill-advised moves he made, suggested a joint lunar expedition. The director of the *Apollo* program, finding himself with something less than a mandate, quit and returned to industry.

Delays, Congressional disputes and squabbles over priorities marked the course of the project. The target date began to drift—from 1967 to 1968 to 1969 and now to 1970.

The U.S. wire services and national newspapers distorted a passing comment by Premier Khrushchev into evidence that the Soviets had abandoned the lunar race. Even when the text of the Premier's statement showed just the opposite—that it was in fact the first official confirmation that the Russians were engaged in a major lunar program—critics of U.S. space spending continued to cite it as support for their case.

As recently as last week, United Press International, one of those most flagrantly responsible for the initial reporting error, repeated it with the statement that Khrushchev "once said in a speech that the Soviet Union was withdrawing from the race to the Moon."

For the record, it should be emphasized that the Soviet Premier has never made such a statement.

Nevertheless, the misquotation was widely coupled with a hiatus in Soviet manned flights as proof that the Russian space program was being abandoned as too costly.

The last Soviet flight before *Voskhod* was the dual June 14-19, 1963, orbiting of spacewoman Valentina Tereshkova and Lt. Col. Valery F. Bykovsky. That gap is considerably less than the current one between the final *Mercury* flight of U.S. astronaut Gordon Cooper in May, 1963, and the first *Gemini* flight now set for next January or February.

Voskhod demonstrated that the pace of the Soviet space program toward an objective chosen by this nation and publicly proclaimed by its President still is much faster than that of the U.S. program.

The achievement of the Soviet Union in successfully orbiting a three-man space vehicle, together with the increasing Russian interest in long-duration space flight, is evidence of an active, well-planned lunar and interplanetary space program.

From the beginning, from Laika to Komarov, the Soviets have displayed an orderly progression to their objective. The *Voskhod* is further evidence of that fact, not in words but in hardware.

"This is the complete answer to those who have been saying that the Russians had lost interest in sending men to the Moon," asserts Kenneth W. Gatland of the British Inter-Planetary Society.

"This success opens new possibilities in the conquest of the cosmos," says Soviet space scientist Leonid Sedov. "It brings nearer the time of immediate contact of men with the Moon, Venus and Mars."

"They are still ahead of us," says Dr. Edward C. Welsh, President Johnson's chief space adviser.

"It was a three-man *Sputnik* that indicated a strong Soviet lead in the race to land a man on the Moon," says United Press International, blandly ignoring its earlier write-off of the Soviet lunar program.

"The Soviet Union's successful orbiting of its mammoth three-man spaceship Monday appeared to be a systematic—and extravagant—step toward the Moon," says the Associated Press, which was equally guilty of distorting the earlier Khrushchev statement.

IT IS NOT SURPRISING that there are those who profess to find a deep Pavlovian plot in the Soviet approach to its relations with the United States. While it is all too distressingly true that the U.S. dances to the Soviet tune, it goes too far to give the Russians credit for this. The responsibility lies with those Americans who cling pathetically to the belief that the Russians are technical incompetents without enough resources to finance a ten-cent telephone call. Every evidence of Soviet achievement therefore causes a spasmodic twitch which then subsides until the next twitch.

The fact is that the Russians are so well along the road to complete domination of space that this nation may never catch them without true belief and support of its own stated objective.

We are the ones who set the course for this race. We are the ones who have asserted that this is a true test of the technologies of the two nations. Never before, short of war, has one nation challenged another in such an expensive, demanding undertaking. The challenge has been accepted by a political system which we insist is inferior to ours, which we proclaim can lead people into slavery but never to the stars.

We cannot back out of this race of our own choosing, upon which we have staked our national prestige. If this were not plain before, the *Voskhod* has made it plain enough now. This nation must put forth a tremendous effort to overtake the Russian lead to the lunar landing.

If we do not, the *Voskhod* will have demonstrated more than the significant Soviet lead in space. It will have demonstrated that we are a nation of fools.

William J. Coughlin

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For full information, send for new four-page descriptive folder. Of course, we'll be glad to recommend the "SCOTCH" Brand Instrumentation Tape just right for your instrumentation needs to use on the new reel. Write 3M Magnetic Products Division, Dept. MBW-104, St. Paul, Minnesota 55119.

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OCTOBER 26, 196

missiles and rockets

THE WEEKLY OF SPACE SYSTEMS ENGINEERING

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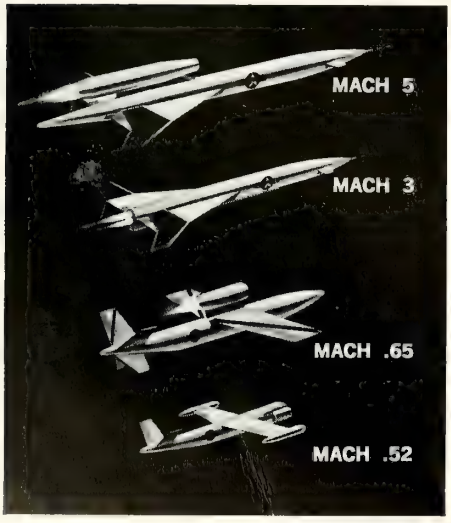
Beech "Imaginuity" in Missile Systems



MACH 7, ANYONE?

What will be the requirements for tomorrow's missile targets? What are the problems in building them? Beech "Imaginuity" is already seeking—and finding—the answers. The Beech missile above, designed to operate at speeds above Mach 7, is just one example of the way Beech is exploring the future—today.

If you want to pass this Beech missile target, you'd better be doing Mach 8—or better!



Now from America's first family of missile targets, comes the newest example of Beech "Imaginuity":

Today's modern air defense systems are only as effective as the shooting skills of the men who aim and fire them. To provide the realistic training needed to keep America's air defense units combat ready, Beech is building and has designed an entire family of missile systems to accomplish a variety of missions. They range in speed from Mach .52 to over Mach 7, with altitude capabilities from sea level to over 100,000 feet.

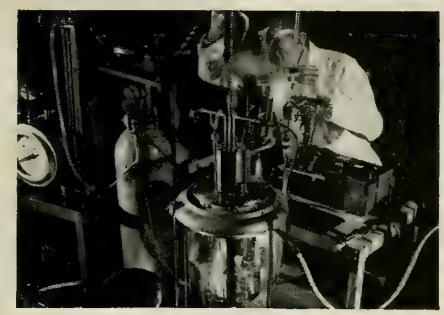
Two Beech missile target systems, the propeller-driven U. S. Army MQM-39A "Cardinal" and the rocket-powered U. S. Navy AQM-37A (KD2B-1), are already being produced in quantity. The AQM-37A is capable now of speeds above Mach 3. It gives today's most advanced weapon systems a realistic challenge to their capabilities.

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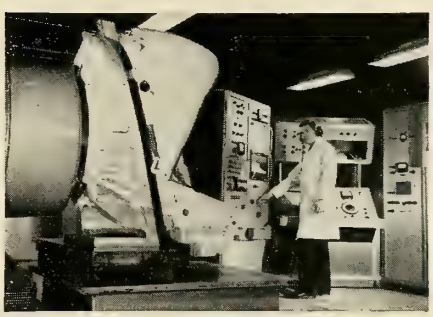
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THE WEEKLY OF SPACE SYSTEMS ENGINEERING

Volume 15, Number 17 October 26, 1964

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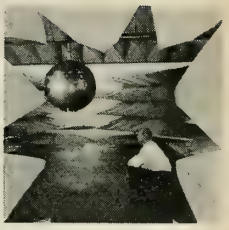
Published each Monday with the exception of the last Monday in December by American Aviation Publications, Inc., 1001 Vermont Ave., N.W., Washington, D.C. 20005. Cable Address: AMERAV.

Printed at Judd & Detweiler, Inc., Washington, D.C. Second class postage paid at Washington, D.C.
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Subscription rates: U.S. and Possessions, Canada, and Pan American Postal Union Nations: 1 year, $5.00, 2 years $8.00, 3 years $10.00. All other foreign: 1 year $15.00, 2 years $25.00, 3 years $35.00. Air freight to Europe: 1 year $20.00, 2 years $30.00, 3 years $40.00. Single copy prices: regular issues 50 cents each; special issues $1.00 each. Subscriptions are solicited only from persons with identifiable commercial or professional interests in the missile/space industry. Subscription orders and changes of address should be referred to Circulation Fulfillment Mgr., Missiles and Rockets, 1001 Vermont Ave., N.W., Washington, D.C. 20005. Allow 4 weeks for change to become effective and enclose recent address label if possible.

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THE COVER



Scientist inspects Atmospheric Explorer B satellite in echo-free vertical test range for antenna radiation measurements at NASA's Goddard Space Flight Center. Pyramid-shaped electromagnetic absorbers are made by B. F. Goodrich Co. to help make room free from radio signal reflections.

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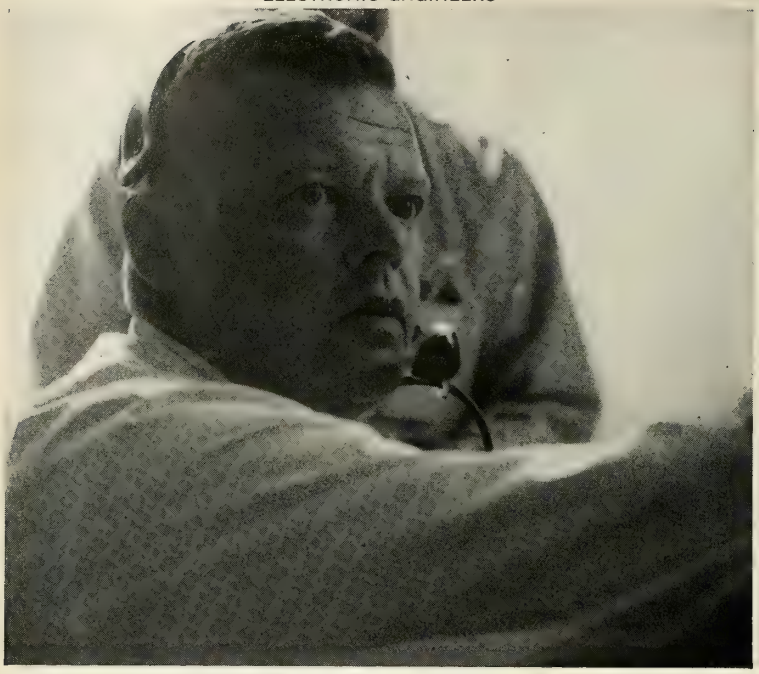
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ELECTRONIC ENGINEERS



IT TAKES GUTS....

and technical savvy... and the ability to be boss...to be a Ship Operations Manager with Pan Am's Guided Missiles Range Division.

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letters

Big Rally II

To the Editor:

I enjoyed your timely and informative article concerning our Big Rally II Communications Systems (M/R, Oct. 12, p. 24). Achieving operational status in five months was, as you noted, a remarkable accomplishment. In this connection, we agree that the contractors involved did an excellent job.

Perhaps the only shortcoming in your brief article was failure to acknowledge the work of several U.S. Air Force officers from Systems Command's Electronic Systems Division who directly supervised the Big Rally II project. The difficulties in operating in the three countries involved, in many cases in remote and inaccessible areas, with language barriers and all the other inherent difficulties of foreign operations, were largely overcome by the project management of three Air Force officers.

It would certainly help the record to note the contribution of Lt. Col. John D. Crisp, USAF, Ret., who managed the project from the Electronic Systems Div. in its early stages, Lt. Col. Garland B. Hilton, who was the Field Manager initially and later took Lt. Col. Crisp's job here at ESD, and finally, Lt. Col. Dewey Edwards, who was the Field Chief for ESD at the time of turnover. These three officers made a notable contribution to the communications capability of the nation.

Donald W. Roberts, Colonel, USAF
Deputy for Communications
Systems Management
Headquarters
Electronics Systems Div.
AFSC
Hanscom Field, Mass.

Squashy Subject

To the Editor:

I'm sure I'm not the first or last to congratulate you on the excellent Oct. 12 editorial ("A Bit of a Squashy Subject").

I don't think any of us has the illusion that a military man (or a newsman) can be bought with a lunch or a tie pin or a jug of bourbon at Christmas.

In fact, the military and newsmen that I know would avoid like the plague anyone they thought was trying to "buy" them. Such an attempt would assure that its originator would never obtain a favor —or even routine help.

Henry Still
Northrop Ventura
Newbury Park, Calif.

Wandering Explorer

To the Editor:

Ref: M/R, Oct. 19, p. 11.

The *Beacon Explorer* satellite was launched Oct. 9 by a *Scout* vehicle from Point Arguello, Calif.; not from Vandenberg AFB, Calif., or Wallops Island, Va., as stated in two different items.

Clyde J. May
NASA-Langley Research Center
Hampton, Va.

Reader May is correct.—Ed.



ANOTHER PERFECT PERFORMANCE BY A ROHR ROCKET NOZZLE

On September 30th Lockheed's 156″ diameter solid propellant rocket motor was fired successfully . . . **with 30% more propellant and thrust than their first successful firing on May 28.** The Rohr nozzle's performance was of special significance because it contained another in a series of Rohr ablative tape-wrapped, hydroclave-cured nozzle liners. Both firings used Rohr insulation components to line the motor cases. Rohr components were fabricated and delivered to meet short Lockheed schedule requirements . . . only 125 days separated the two firings. This test brings to 12 the number of large solid booster firings and 12 straight successes of these large Rohr rocket components. This is full reliability. This is full performance. For full information on large rocket component capabilities here, please write Marketing Manager, Space Products Division, Dept. 91, Rohr Corporation, 8200 Arlington Avenue, Riverside, California.

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An advanced degree plus five years or more experience in rocketry is required for most positions, although there are some openings for new college graduates. Experience in flight hardware is desirable. We also have positions available in non-project work for creative scientists and analysts.

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The Countdown

WASHINGTON

Centaur, SA-9 Launches Held Up

Two more NASA launchings have been delayed. The fourth *Centaur* flight—originally slated for this month—has now slipped to about Nov. 17. At the same time, problems with the *Pegasus Meteoroid Detection Satellite* have forced officials to put off the *Saturn SA-9* flight until late this year or early next. It had been scheduled for the third quarter of this year.

STAFF Flight Still Possible in '64

STAFF—the Stellar Acquisition Flight Feasibility program—took a significant step forward when it finished acceptance tests recently. This raises the possibility that the Air Force project to prove the feasibility of the stellar inertial guidance system could still chalk up a flight this year. The flight-test program, which will use six excess *Polaris* missiles, was originally scheduled to achieve its first flight test in early 1964. If the test vehicle, now undergoing proof tests in the environmental chamber, successfully completes this phase, a shot may yet be made before January.

Fluorine Boosting RL-10 Performance

NASA is continuing its study of the application of fluorine in the RL-10 engine. Certain changes in the powerplant have already increased its specific impulse from 425 to 435 seconds. Use of fluorine is expected to add another 25 seconds.

Phoenix Is Key to Navy TFX Progress

Development of the *Phoenix (AIM-54)* air-to-air missile for the Navy version of the TFX and its associated fire-control system are the pacing items in the aircraft development program. They are advanced versions of the *AIM-47A* missile and ASG-18 fire-control system used in the Air Force YF12A.

U.S., Soviet To Share Mars Launch Period

Launch window for this year's *Mariner* Mars flight opens Nov. 4 and closes shortly after Dec. 1. While two U.S. spacecraft will be started on their eight-to-nine-month journey to the planet, the Soviet Union is also expected to shoot probes to Mars. Thirteen previous Russian attempts to explore the planets have yielded only one partial success.

JCS Presses Aircraft Penetration Study

A Joint Task Force (JTF-2) has been established by the Joint Chiefs of Staff to conduct a series of tests of both offensive and defensive aspects of aircraft penetration. Commanded by Maj. Gen. George S. Brown, USAF, the group is expected to have an eventual strength of 200 people. It will be permanently assigned at Sandia Base, Albuquerque, N.M.

Navy Moves Further into MOL Program . . .

Navy has set up a field office at the Air Force Space Systems Div. for "implementing and executing" Navy plans for participation in the AF's *Manned Orbiting Laboratory (MOL)* program.

. . . And Maxwell Hints at VAFB MOL Flights

Brig. Gen. Jewell C. Maxwell, commander of the Western Test Range, Vandenberg AFB, predicts that manned space flights eventually will take place at that base. Indications are he is referring to *MOL*, since Space Systems Div. sources commented earlier that *MOL* may go on some polar-orbit missions.

Range Commanders Pow-Wow at Cape

Commanders and staffs of seven missile ranges are comparing notes this week at a two-day (Oct. 27-28) council at Patrick AFB, Fla. Attending are chiefs of the Army White Sands Missile Range, Naval Ordnance Test Site, Air Force Eastern Test Range, Pacific Missile Range, Air Force Western Test Range, Air Force Flight Test Center and Air Proving Ground Center. Agenda includes a briefing on the AFSC National Ranges Division and discussions of interrange missile ground safety, flight safety, global planning, communications, operations and data reduction.

INDUSTRY

'Lunar Scooter' Prepared for Testing

North American Aviation's "lunar scooter"—a one-man space transportation platform—is due to be given its first zero-g tests in an Air Force C-135 at Wright-Patterson AFB in about two weeks. It's a low-thrust jet-lifted device somewhat resembling ducted-fan flying platforms the Navy has studied for use on Earth. In the Wright-Pat tests, ski boots and bindings will be used to tie the operator's feet to the platform, which he will steer with his ankle muscles. Earlier Earth-gravity tests employing a compressed-air jet fed by umbilicals have indicated that the scooter is easier to control than earlier ducted fans, which the operator controlled by shifting his weight on hand-rails.

LEM Engine Passes Early Testing

TRW Space Technology Laboratories reports successful high-altitude tests of its Lunar Excursion Module (LEM) descent engine at the firm's new Capistrano test site in southern California. On its third test, engine ran for 136 secs. and throttling range was extended from 100% to 10% of maximum thrust. Engine is being developed under a parallel program for Grumman, LEM prime contractor. STL's concept uses variable area, coaxial injector and cavitating venturi flow control valves to achieve thrust variation over 10 to 1 range.

Aerojet May Meet West Coast Reaper Gap

Aerojet-General Corp. may undertake the development and manufacture of harvesting machines, as a diversification move and to help meet a threatened farm labor shortage in California. R. H. Dow, manager of the company's Test Instrumentation Div., told a meeting of state legislators recently that a recommendation will be made soon that Aerojet proceed with plans for such a program. Dow was among several witnesses who testified at the gathering, which considered solutions to a farmhand shortage expected to develop after Dec. 31, when importation of Mexican laborers becomes illegal.

INTERNATIONAL

Japanese Eyeing Redeye

Another boost for the *Redeye* program (see p. 10) is the anticipated visit of two Japanese missions interested in procuring the system for their Ground Self-Defense Force. The Japanese have expressed a desire to visit the *Redeye* production facilities at General Dynamics/Pomona. The Japanese are also interested in a Swiss surface-to-air missile.

The Missile/Space Week

DCA To Employ Titan III-C

The initial Defense Communications Satellite Program will use the *Titan III-C* launch vehicle to place six to eight satellites into a quasi-synchronous equatorial-plane orbit at an altitude of 19,500 mi., Rear Admiral Francis E. Boyle, Deputy Director of the Communications Satellite Project Office in the Defense Communications Agency, has told the National Space Club.

DOD has thereby openly rejected the Holifield subcommittee report on defense communications satellites, which strongly recommended that the Defense Dept. use the *Atlas-Agena* as launch vehicle for its communication satellites.

Adm. Boyle described the launching of military comsats by saying that after the transtage carries a payload to altitude, a "retro-thrust engine" will give each satellite a differential velocity as it is dispensed from the carrier. Using this technique, the satellites will slowly expand their orbits to form a circular plane giving satisfactory Earth coverage between 70-degree latitude parallels. By controlling the velocity differentials, this coverage will exist for a period of about one-and-a-half-years before a gradual conjunction of the satellites occurs, Adm. Boyle explained.

ComSat Seeks Consultant

The Communications Satellite Corp. has invited 15 firms to compete for a ground station design and operation consultant role similar to one assumed some two years ago by International Telephone and Telegraph Corp. for the Defense Communications Agency.

Three of the 15 firms, however, are already contesting ComSat's pending claim for exclusive ownership of the first several ground stations. ComSat has filed a defense of its claim with the Federal Communications Commission.

Firms receiving the invitations are: American Telephone and Telegraph, Bendix Corp., Collins Radio, General Electric, Hughes Aircraft, International Telephone and Telegraph, Page Communications, Philco, Radiation, Inc., RCA, Raytheon, TRW Space Technology Laboratories, Sperry Rand, Sylvania and Westinghouse Electric.

AT&T, ITT's Intelcom subsidiary and RCA have told the FCC they oppose giving ComSat exclusive rights to build and operate the first ground stations.

The company ComSat contracts with for the consultation services will be barred from providing actual station hardware, as was Intelcom in the DCA agreement (M/R, Sept. 24, 1962, p. 13).

Shillelagh, Redeye Score

Two Army missile systems, *Shillelagh* and *Redeye*, have enhanced their records with recent successful test firings. The *Redeye* launch results boosted hopes for FY '66 funding for the program, while the *Shillelagh* firings were described by prime contractor Philco Aeronutronic Div. officials as "the acid test" for the missile.

The shoulder-launched *Redeye* anti-aircraft missile scored a direct hit Oct. 7 on a jet-powered drone flying at 421 knots at China Lake, Calif. General Dynamics/Pomona is prime contractor for the weapon, which scored a partial success in firings two weeks earlier (M/R, Oct. 5, p. 16).

The program has been operating on limited funds since Congress cut $19 million from the Army FY '65 request for the system, and slashed another $10.5 million in FY '65 Marine Corps *Redeye* money.

The *Shillelagh* scored hits on both stationary and moving targets in late September and early this month at White Sands Missile Range, N.M. The anti-tank missile was fired by troops from Ft. Knox, Ky., who had no previous experience with the system.

Shillelagh has been approved for production in the Army's FY '65 budget. These most recent tests came after a four-month conditioning period during which the missile was subjected to extremely hot and extremely cold temperatures, as well as special vibration tests.

DOD 'Standards' Hit

Two major military associations have condemned the recent DOD Standards of Conduct Directive in open letters to Secretary of Defense Robert S. McNamara.

Both the American Ordnance Association and the Air Force Association accused defense officials of impugning the integrity and judgment of the department's military and civilian personnel.

Gen. Arthur G. Trudeau, USA (Ret.), AOA president, wrote to McNamara, "We regret that you found it necessary to impose such stringent regulations in your recent amendment to the DOD Standards of Conduct Directive."

AFA president Jess Larson, a major general in the Air Force reserve, questioned the wisdom and propriety of "tarring the many innocent with the brush that is meant for the guilty few."

Larson noted that President Johnson in a recent speech to the students at the National War College had said "there is a strong mutual confidence between military men and civilian political leaders."

If the Standards of Conduct Directive had been in effect when the President made that speech, Larson said, the President would have been compelled to add "except in the Department of Defense."

Sea Launches Set for IQSY

NASA will launch 40 or more scientific experiments from a seagoing converted aircraft transport during a three-month expedition next year.

The launches will be part of the sounding rocket program being conducted during the International Quiet Sun Year, 1964-1965. Solid-fueled *Nike-Apache* and *Nike-Cajun* sounding rockets will carry the experiments to areas of the upper atmosphere and ionosphere that cannot be reached by land-based rockets. *Arcas* and *Hasp* weather rockets will also be fired from the transport.

DOD Briefings On Again

The series of advanced planning briefings for industry, scheduled for September and October and then cancelled by the Dept. of Defense, have been reset for March and April, 1965.

First of the series of unclassified briefings, sponsored by the National Security Industrial Association, will take place in Los Angeles March 3-4. It will be followed by sessions in New York City, Chicago, Dallas and Washington, D.C.

The previously scheduled sessions were cancelled when the Pentagon decided that holding the briefings in the pre-election months might be construed as "partisan activity."

Objective of the briefings is to

provide business, industry and labor with a picture of DOD's long-range development needs and to assist industry in planning for and seeking defense contracts.

Shots of the Week

Japanese and American scientists used a *Javelin Argo D-4* sounding rocket to carry 125 lbs. of scientific payload to 521 miles altitude Oct. 19 from Wallops Island, Va. The devices sent aloft were to measure electron and ion temperatures and densities.

- Britain successfully launched its second *Blue Streak* booster from Woomera, Australia, Oct. 20. The flight was apparently a complete success. The earlier shot in July fell short of its intended altitude because of a premature engine shutdown. A third firing of the rocket, which is to serve as the first stage of the European Launcher Development Organization vehicle, is now set for next March.
- NASA on Oct. 21 fired an *Astrobee 1500* sounding rocket 1,212 miles into the sky above Wallops Island, Va. The shot carried with it instruments for a variety of scientific tests.

Astor Follow-On Open

Six firms are bidding for follow-on production of the *Astor* Mark 45 antisubmarine torpedo. However, the Bureau of Naval Weapons refused to identify the companies seeking to win the follow-on contracts.

Westinghouse until now had been developing the nuclear torpedo and no matter who wins the production contract itself, Westinghouse will retain design cognizance of the overall *Astor* program.

Arnold Moves to West Coast

The USAFS Gen. H. H. Arnold, in service on the Air Force Eastern Test Range since mid-1963, will be shifted to the Pacific Ocean late this month.

The Gen. Arnold will serve as a primary tracking ship of the Air Force Western Test Range for missile and space programs launched from Vandenberg AFB. The ship will supplement instrumentation on the Pacific range.

USS Ricketts Displayed

Secretary of State Dean Rusk has called the USS Claude V. Ricketts—the mixed manned demonstration ship for the multilateral force—"tangible evidence" of U.S. intentions to pursue the MLF concept.

A visit of the Ricketts to Washington last week was in formal recognition of "a promising venture in alliance military unity." The guided missile destroyer visited Washington to provide an opportunity for representatives of the seven participating NATO countries to observe the current status of the demonstration ship.

Of the 18 officers and 316 enlisted men, there are included personnel from the navies of the United States, Federal Republic of Germany, Greece, Italy, Turkey, the Netherlands and the United Kingdom.

Secretary Rusk reaffirmed U.S. determination to push the MLF concept of 25 surface ships each armed with eight *Polaris* missiles. With the exception of West Germany, most of the nations of NATO have been lukewarm to the proposal and only recently the MLF was dealt another blow with the election of a Labor government in Britain.

SA-9 Parts Head for Cape

The barge "Promise" is en route to Cape Kennedy with the *SA-9* first-stage *Saturn* booster and instrument unit. It is due to arrive Oct. 30.

The S-IV second stage was scheduled to be flown from the West Coast to the Cape during the past weekend.

A boilerplate *Apollo* Service Module will be flown Nov. 12 from Marshall Space Flight Center to Cape Kennedy. The boilerplate *Apollo* Command Module to be used on the flight is already at the launch area.

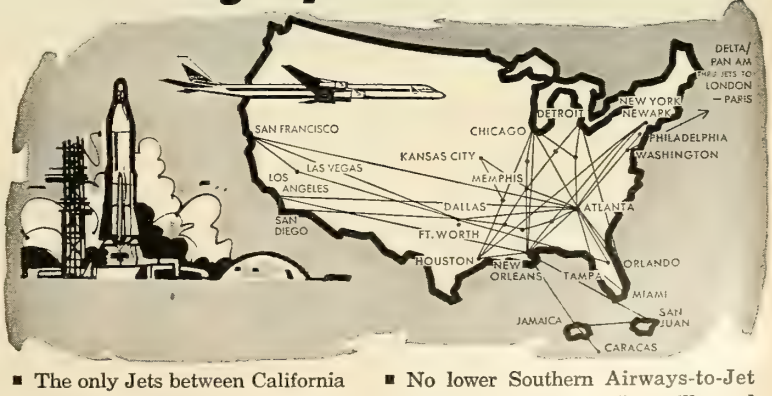
Defense Spending Falls

Defense spending for the first three months of Fiscal Year 1965 fell $700-800 million below the spending rate of the first three months of Fiscal '64, Secretary of Defense Robert S. McNamara has revealed.

The reduced defense spending was largely responsible for the overall $41-million saving in government expenditures during the first three months of the current fiscal year. The difference between the DOD saving and the overall government figure was largely dissipated by military and civilian pay raises which became effective during this period.

In discussing the Fiscal '66 budget, McNamara last week declined to say whether it would be lower than this year's $51.2 billion figure. He did say, however, he felt confident that defense spending would take a decreasing percentage of the Gross National Product.

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Another fuel cell application/success report from Allis-Chalmers:



World's first fuel-cell operated submarine!

July, 1964, Groton, Conn.: Star I — a one-man test and research submarine — was successfully operated both submerged and on the surface. An Allis-Chalmers 36-volt fuel cell produced 750 watts to power the vessel's electric drive motors, communications, navigation, life support and lighting equipment.

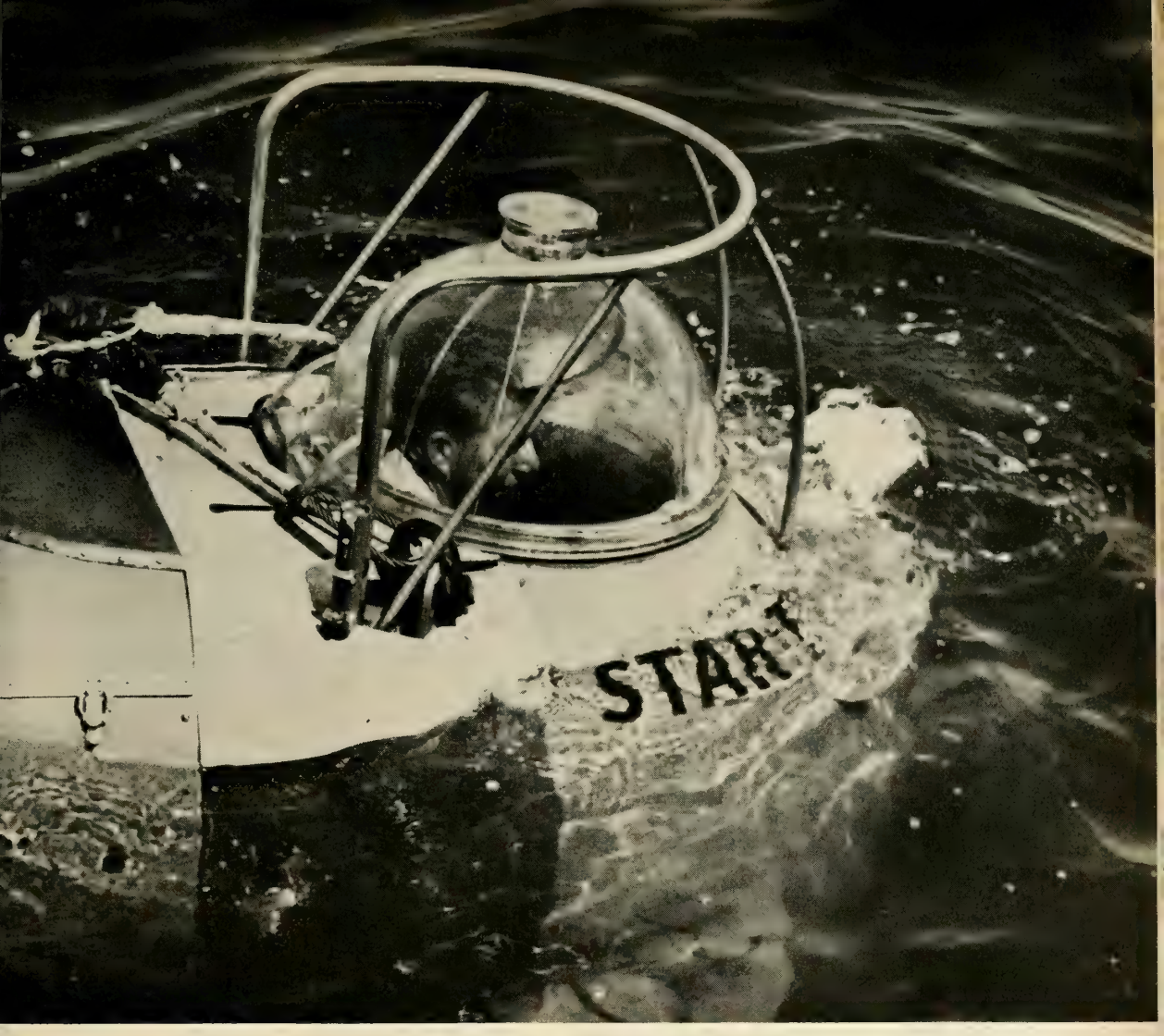
Star I — owned and operated by General Dynamics/Electric Boat Division — was powered by an Allis-Chalmers fuel cell system. It is a nine-foot-long, teardrop shaped 2,500 lb. submarine. A-C and Electric Boat Research engineers teamed up to successfully adapt fuel cell power to the submarine. Purpose: **to extend the vessel's capabilities beyond those of conventional storage battery power.**

In effect what the fuel cell has demonstrated was to double the Star I's endurance time. Previously batteries lasted up to 4 hours and required 8 hours to recharge. In the fuel cell, endurance is measured by the quantity of fuel and oxidant aboard and only five to ten minutes are sufficient to change to a fresh supply of hydrazine (the fuel) and oxygen (the oxidizer).

And this new Allis-Chalmers fuel cell application follows on the heels of A-C's 14 lb. hydrogen-oxygen fuel cell developed for the Air Force. This cell qualified for orbiting. It's scheduled to produce electrical power for systems aboard aerospace vehicles.

May we discuss your aerospace or defense fuel cell application? TELEPHONE AREA CODE 414-774-3600, EXT. 491, ALLIS-CHALMERS, Box 512, Milwaukee, Wis. 53201. A-1939

ALLIS-CHALMERS





The compact Allis-Chalmers fuel cell is ready for lowering into the non-pressurized glass fiber fairing behind the STAR I's four-foot spherical pressure hull.



In July, 1964, the 9-foot long STAR I, powered by A-C fuel cells, operated successfully both submerged and on the surface.

Quick summary:
ALLIS-CHALMERS FUEL CELL FIRSTS

FIRST
. . . in a land vehicle, a 15-kw tractor 1959

FIRST
. . . to successfully pass zero gravity tests, Wright Patterson AFB 1961

FIRST
. . . "qualified for space" fuel cells for the Air Force. . . . March, 1964

FIRST
. . . to power an underwater vehicle . . . . . July, 1964

FUEL-CELL design for Aerospace and Hydrospace applications is but one of the opportunities open today for qualified scientists and engineers at Allis-Chalmers. For information concerning employment write to: Manager of Professional Placement, Allis-Chalmers, Milwaukee, Wisconsin 53201.

Circle No. 4 on Subscriber Service Card

Post-Apollo Programs Detailed

Says Air Force MOL and Apollo-X do not compete; program definition for latter will be in FY '66 budget

by Hal Taylor

DR. ROBERT C. SEAMANS, JR., NASA's general manager, has detailed the agency's plans for post-*Apollo* space programs, including program-definition of the *Apollo-X* spacecraft in the FY '66 budget.

The agency's associate administrator, in an interview with MISSILES AND ROCKETS, also declared that a NASA space station with a six-month to one-year lifetime will not receive hardware funding until the 1970's.

He declared that the Air Force's *Manned Orbiting Laboratory (MOL)* program does not compete with *Apollo-X*. "*MOL* is important for the military as a method of determining what opportunities there are for men in space. It is not suitable to fulfill NASA requirements to gain scientific knowledge," he said.

Dr. Seamans stressed that all of the agency's plans are contingent upon coordination with the Defense Department, and approval of the Space Council, Budget Bureau, and ultimately, the President.

● **Three broad categories**—He declared that NASA's space program can be broken down into three major areas, including:

—Approved programs calling for Earth orbital flights of one to two weeks with the *Gemini* and *Apollo* spacecraft, and rendezvous, circumlunar and lunar landing missions.

—The second phase, which will involve continued utilization of existing systems but with extended capability.

—The third phase, which calls for involved advanced projects using major new development programs.

● **Phase II detailed**—Much of the second-phase follow-on program will be initiated in the budget that will go to Congress in January.

In general, this phase will include Earth-orbit flights of one to two months; polar orbit missions; manned synchronous flights to study radiation; new life-support equipment and power supplies capable of supporting long-duration missions; lunar mapping; rendezvous flights for in-orbit inspection and repair; extending astronaut stay time on the Moon by using existing systems; unmanned exploration of Mars with the heavy *Mariner* and *Voyager* spacecraft.

In terms of specific projects, the second phase will involve, according to Dr. Seamans, the initiation of detailed design and project definition in FY '66 of the *Apollo-X* spacecraft. He also declared that there will be some hardware funding of certain of the spacecraft's systems and sub-systems.

"While our plans call for an early start," he said, "it must be recognized that the plans and schedule for this project will depend upon the progress made in existing approved programs."

Turning to extended lunar exploration, he said there is a possibility that the so-called unmanned Lunar Excursion Module truck spacecraft will also go to the program-definition phase in FY '66. This will depend upon current studies of its technical feasibility. The spacecraft, which would be the *Apollo* spacecraft's Lunar Excursion Module minus the equipment and life-support system needed for manned flight, would be used to carry the supplies required to support extended manned lunar exploration.

Unmanned exploration of Mars in the second phase will begin with a heavy 7,000- to 9,000-lb. *Mariner* spacecraft in 1969. The best bet for the launch vehicle now appears to be the *Saturn IB/Centaur* combination. Although admitting that the vehicle has about the same payload capability as the Air Force's *Titan III*, the NASA officials said that funding in FY '66 is currently under review. He said that adding a third stage to the *Saturn IB* appears to be a logical extension of its capability and the chances of approval are good.

The *Voyager* spacecraft—which initially will also be launched by the *Saturn IB/Centaur* combination—will be funded in FY '66. Dr. Seamans said that it will involve a series of missions including orbiting flights around Mars, ejections of capsules into its atmosphere and the landing of a capsule on the surface of the planet.

● **Phase III farther away**—A start on NASA's planned third-phase program is much farther down the road. The advanced projects phase will include space stations with a six-month to one-year lifetime and with a resupply capability, *Mobile Laboratory (MOLAB)* for extended lunar exploration leading to a lunar base, post-*Saturn-V* launch vehicles, recoverable boosters and lifting body re-entry vehicles.

All of these, he said, will involve major new developments and there will be no hardware funding available for them until the 1970's. He added that there is a possibility that some subsystem or component work will be started before that period.

In discussing other elements of the U.S. space program, Dr. Seamans also said that:

—The agency still plans to have its detailed report on its future space program in the hands of the President in time for it to be meshed in with the FY '66 budget planning.

—High NASA officials are not convinced that the uprating of the *Saturn IB* and *Saturn V* booster stage is necessary. It is unlikely that any work will be started on the projects in FY '66, but such a possibility is not ruled out completely.

—NASA development of a fluorine engine will not occur until at least FY '67. ■

In DOD reply to GOP . . .

New Missiles Get 'Left-Handed' Okay

Sylvester response to McElroy group's criticism is first indication to Air Force, Navy that systems had been approved

by James Trainor

A POLITICAL EXCHANGE between the Defense Dept. and the Republican Task Force on "Peace Through Preparedness" has turned out to be a program-approval document for three major weapons systems, much to the surprise of the Air Force and Navy.

In replying to the committee, composed of former military and defense officials and headed by former Secretary of Defense Neil H. McElroy, Assistant Secretary of Defense for Public Affairs Arthur Sylvester gave the Navy and the Air Force their first indication that DOD had approved three new weapons. The three are:

—*SRAM*, described as an air-to-surface missile.

—*Extended Range Asroc*, an anti-submarine missile.

—*ARM 1*, an anti-radar missile.

These were included in "a laundry list" of programs "initiated during 1961-1964." The two services were embarrassed and unable to supply any further details on the three systems until they "can check with the Defense Dept. and see what else could be said."

In the case of *SRAM*, the Air Force had forwarded a program package to the Directorate of Defense Research and Engineering. However, until Sylvester's statement, it had not received notification that funds had been provided for the program. As MISSILES AND ROCKETS went to press, the service still had not received an "official" go-ahead for the air-to-surface missile.

Questioned regarding the two Navy programs, officials declined to go beyond the Sylvester statement.

● **Missile descriptions**—*SRAM* is a defense suppression weapon for use on strategic bombers. The original conception envisioned the use of such a missile on the Advanced Manned Strategic Aircraft. However, this program has not been approved and is a source of considerable controversy in the Defense Dept. and in the Presidential election campaign. *SRAM* has been adopted, therefore, as additional armament for the B-52.

Such a missile probably would be carried in addition to the *Hound Dog* missiles already aboard B-52's. *SRAM* could be used, as the name implies, for destruction of enemy air defenses in the penetration corridor. *Hound Dog*, in contrast, would be used as a stand-off weapon so that the attacking aircraft would not have to fly over heavily defended areas.

Extended Range Asroc is a Navy program to extend even further the distances at which a surface ship can engage in destroying anti-submarines. Like its predecessor, the Extended Range version most likely would carry Mark 44 or Mark 46, Mod 0 or Mod 1 torpedoes or a nuclear depth charge. Range of the present *Asroc* varies from 1,800 yards to 8 n. mi. The new version probably would at least double this maximum range.

Navy officials told M/R earlier this year that such a range increase could be achieved solely through the use of improved propellants. Parenthetically the Navy is developing a version of *Asroc* that can be fired from carrier launchers. However, this is basically just a modification of the *Terrier* rail launcher to accept an anti-submarine weapon.

ARM 1 is an anti-radiation missile designed to home on the electromagnetic signals from defense of radars. Although the program has been and remains shrouded in secrecy, it appears to be a more advanced version of *Shrike* —probably as armament for the F-111B (TFX) and the A-7A (VAL) aircraft.

This missile would no doubt be able to handle a wider range of frequencies and be smaller and lighter than *Shrike*, which basically was an adaptation of *Sparrow III* for the anti-radiation mission.

● **McElroy report**—The Republican Task Force charged that "there are increasing and deeply disturbing indications that the present Administration has for four years neglected and stifled innovation, thwarted origination of new systems and cancelled promising projects."

To support this charge, the Task Force included a box score of missiles and aircraft developed during the Eisenhower years as opposed to those developed during the Kennedy-Johnson years. The score, according to the committee, stands at an impressive 57 for Eisenhower to 8 for Kennedy and Johnson.

Sylvester criticized the report as "an inaccurate picture of this nation's military research and development policies and programs," Citing specifically the charts in the McElroy report, he said that they are "typical of the inaccurate information" in the report. He pointed out that these charts compared the three years of the present Administration to the eight years under Eisenhower. In an attached list he provided "some of the omissions and mistakes made in the chart." It was in this attachment that Sylvester revealed that *SRAM*, *Extended Range Asroc* and *ARM 1* had been "initiated." Among the other projects he listed were Counter Insurgency (COIN) aircraft, the SR-71, the RF-4C (a tactical reconnaissance aircraft), *Minuteman II*, *Nike-X*, *Walleye*, *Polaris A-3* and the XC-142 (an experimental vertical take-off/landing aircraft).

Among the mistakes in the report, Sylvester listed six aircraft and one helicopter that had been developed either by private industry or, in one case, a foreign government. He also claimed credit for the *MMRBM*, which he said was not started until 1962.

Members of the Task Force, in addition to Mr. McElroy, included former Sen. Prescott S. Bush (R-Conn.), Rep. Gerald Ford (R-Mich.), Wilfred McNeil (former comptroller of the Defense Dept.), Adm. Arthur Radford (USN) Ret., and Gen. Nathan F. Twining (USAF) Ret. The latter two were both chairmen of the Joint Chiefs of Staff in the Eisenhower Administration. ■

A Special M/R Feature—

Views of the Presidential Candidates On the Future of the U.S. in Space

President Johnson stresses values of broad international cooperation; Senator Goldwater would work first with Allies, 'balance' Moon program





IN THE YEARS of office of our next President—whether he be Lyndon B. Johnson or Barry M. Goldwater—the United States will take fateful steps in the areas of space exploration and defense.

On these pages, MISSILES AND ROCKETS *presents statements by both candidates on some of the issues involved in space and defense. President Johnson's remarks are excerpted from recent speeches and messages, since the White House has established a policy during the campaign of not preparing specific statements for individual publications. Senator Goldwater prepared his statement in direct response to a request from M/R.*

President Johnson

Briefing on Ranger VII Mission, Aug. 1, 1964

I want to say, before you conclude, that all Americans are very proud of you today. We are proud of this historic extension of man's knowledge. We are proud of our scientists,

Senator Goldwater

IN many areas of research and development, the Federal Government has spent great sums of the taxpayers' money. I do not argue that these sums should be either increased or decreased as a general proposition. In some areas, clearly they may be increased advisedly—in other areas, great economies

. . . Johnson

our engineers and all the great team under the leadership of one of the greatest of all Americans, Jim Webb, who are responsible for this success. We can be duly proud of our free and our open society, our system of government.

We started behind in space. We were making many apologies just a few years ago. We had our failures, but we kept our faith in the ways of freedom, and we did not follow the easy or the inexpensive course.

We know this morning that the United States has achieved fully the leadership that we have sought for free men. But we do not claim this as an American triumph alone.

● **International cooperation**—In the brief period of time that I have occupied this office of the Presidency, I have visited with the leaders of many countries—more than 25, and less than 50, some 30 of them—big countries and small countries, densely populated peoples, sparsely populated regions, but I have found a deep and exciting interest among all these leaders in cooperating with us and extending their hands to us to supplement the work that we are doing. I thank them for their tracking stations. I thank them for their joint participation with us. We have considered this adventure a truly peace weapon, rather than a military might.

I think we can say this morning that this is a victory for peaceful civilian international cooperation in this hour of frustration, when so many people are getting upset at some minor disappointments. I think we can all take great pride in this development. More than 60 countries all around the world work for us and work for peaceful progress and work for peaceful uses of outer space. It is good to learn from this event that we are on the right course. We know that if we can continue on that course, and if you great scientists—most of whom know no party and no political allegiance, and who are concerned with freedom first and America second—if we continue to give you support without any tinge of partisanship, you will give us the leadership and ultimately the supremacy in an area that is essential to the prolongation of civilization itself.

If we could only supplant the fear and the hate, the bitterness and the division, the poison and the venom that our fellow man contains, with the hope and the optimism and the achievements represented by this venture here, how much better our world will be for ourselves, our children, and our grandchildren.

● **Defense dividends**—I want to say this in conclusion. In this century in which we live, all my life we have been either preparing for war or fighting a war or protecting ourselves from war. When I grew up as a kid, one of my first real memories was hearing the powder go off on an anvil on Armistice Day. I remember the terror that flowed from the sinking of the Lusitania. I remember seeing the boys come marching home, and the welcome we gave them in our little school house. I remember leaving, the day after I voted, to go to Pearl Harbor and crossing the Pacific, and later the Atlantic, and all the men who gave their lives to win in World War II.

I have seen the billions and billions of dollars we have spent in the 17 years since that war to protect western civilization. Now I think it is the most powerful nation in the world, and I would remind you that we spent $30 billion more in the last four years on defense alone than was being spent four years ago. We were spending about $42 billion a year then, and we are spending $51 billion now. So $7.5 billion extra a year for four years is $30 billion. That has bought a good many more missiles, and that has bought a good many more combat-fit men. That has bought a good many more anti-submarine weapons, and it has bought a great deal more research.

● **Spinoff**—But now, today, as the most powerful nation

. . . Goldwater

are possible without harm to the essential programs.

Today the greatest dollar amount in governmental research is spent in the effort to place men on the Moon. On the space program alone, we are spending about $5 billion each year in spite of negative advice from our leading scientists. There is inspiration in lifting our eyes and hopes to the stars, but a more balanced program and one much more carefully considered than has been the case in the past four years is urgently required.

● **Priorities**—Man should indeed explore the Moon, but I see no good reason why we must incur the large unnecessary expense of a crash program. The first man on the Moon will probably not gain for us any vital military advantage.

Rather than racing to send a man to the Moon, we can and we should send more instruments. Man will and should follow. But we ought to get to the Moon to collect facts and not to impress the world by our extravagance with money and talent.

The great enterprise of exploring the Moon and the planets is not a job for America alone. It is rather an area for international cooperation. Effective cooperation can be carried out if the task is divided, and responsibility is allotted in an effective manner. But in such cooperation, I would give first priority to joint work with our Allies—the advanced free democracies—rather than with the Communist nations. It is with our Allies that maximum advantage can be obtained from the free exchange of ideas.

It is a mistake to attempt international cooperation in every instance as we have been doing, by first inquiring whether the men in the Kremlin deign to cooperate with us. They have said often and clearly that such cooperation is subject to their long-range goal of world mastery and the destruction of free governments.

Travel to the Moon and to the planets is a wonderful prospect, but it is also a distant prospect. We shall not achieve this goal unless we make full use of the small but powerful packages of energy that reside in the atomic nucleus. Today, the Administration is evidencing no enthusiasm on means for atomic space travel. Yet the imaginative use of atomic energy may prove to be the key that unlocks the way to the stars.

If we pursue the goals of exploring outer space in an imaginative and yet orderly way; if we work with those who will work with us in full cooperation and frankness; if we put the less difficult goals first and let the more difficult ones follow—then, indeed, the expense of the space program to the United States can be very greatly reduced without sacrificing the long-range scientific objectives. This is but one example of how great economies can be achieved.

● **Near space**—The exploration of space in the immediate neighborhood of our planet has a much more direct bearing on our safety. The recent launching of the large manned Soviet satellite clearly emphasized this fact. And it is here that we have permitted them to surpass us. Communications, surveillance of the globe and weather observations are among the early fruits of this work, and more effort along these lines will have to be supported. In an uneasy world divided by the Iron and Bamboo Curtains, surveillance from satellites can be made a bulwark of peace and a source of desperately needed information and warning for us. President Eisenhower proposed the "open skies" policy even before the skies were opened by the satellites. Today we develop the open skies policy into a reality which can serve the security of all peaceful nations.

The freedom of space is as important to us today as the freedom of the seas has been to our fathers.

The scientific ingenuity of man should be directed not only toward the prevention of war but dedicated to the im-

. . . Johnson

in the world, why do we have satisfaction from that? Not just because it protects our scalps and allows us to sleep at night knowing that we are safe, but it gives us the opportunity to enjoy the fruits of this society and to develop this land, not just with parks and recreational areas, highways and swimming pools, things of that kind, but all the blessings that are going to flow from these scientific discoveries and achievements. Hundreds of lives, millions of dollars were saved in Hurricane Carla in my state alone because they gave them hours of advance notice to get ready. "This is coming, and your lives are going to be snuffed out if you don't get out of the way."

They rode bumper to bumper for dozens of miles getting out of there, 48 hours before it hit. That is what it means to you and to your neighbors.

Our military muscle has grown while budgetary fat has been trimmed away.

We are the richest Nation in the history of the world. We can afford to spend whatever is needed to keep this country safe and to keep our freedom secure. And we shall do just that.

But we cannot afford to spend one dollar more than is absolutely necessary because we have other needs to meet with those dollars—public needs and private needs.

Address at a DOD ceremony observing Cost Reduction Week, Pentagon, July 21, 1964

I can tell you with positive assurance that your country has never been stronger militarily than it is at this hour. I can tell you without the slightest fear of contradiction that for the next months that I am going to be in this office, we are determined to keep it that way. We are always going to keep our guard up but our hand out, searching for some way to avoid a nuclear holocaust. We are determined that no nation shall ever exceed us in preparedness and none shall ever exceed us in the pursuit of honorable peace, for we shall keep both our reason and our readiness at all times.

Address to the U.S. Chamber of Commerce, Washington, D.C., April 27, 1964

The U.S. space program is designed to maintain our position of leadership in the Free World. Cooperating with other nations in many areas of space technology and pressing for ever-widening participation and distribution of space benefits, the U.S. has led the world effort in this area. It is in the national interest—economically, technically, scientifically, militarily and internationally—to carry this program forward in an accelerated fashion so that the U.S. will obtain for mankind every one of its many benefits as soon and as efficiently as possible.

Report to Congress January 27, 1964

To preserve and protect our vital national interests in these recent years of uneasy peace, this Nation has invested heavily in the improvement of its defenses. We have chosen not to concede our opponents supremacy in any type of potential conflict, be it nuclear war, conventional warfare or guerrilla conflict. We have now increased the strength of our forces so that, faced with any threat of aggression, we can make a response which is appropriate to the situation. With present forces and those now planned, we will continue to maintain this vital military superiority.

Budget Message for FY 1965 January 21, 1964

. . . Goldwater

provement of the peaceful conditions in which we live. Looking Earthward from the satellites, we have begun to observe the clouds which shroud the globe. We can now measure the precise state of the atmosphere over the continents and over the oceans. In the foreseeable future, this will lead to better prediction of weather and, quite possibly, to the modification of weather on a local or on a global scale. Its beneficial effects on agriculture suggest an enterprise of such dimension that it cannot be undertaken by any organization less than the Government.

If we focus our attention first on that part of space in which our own Earth is orbiting, we can reap the greatest and most important benefits and insure our own security. We can then penetrate into more distant space under less pressure to make haste. Whether greater knowledge is to be brought to the Earth from outer space or is to be discovered in the microcosm of the atom, such knowledge in due course will influence our daily lives, our well-being and our security. I pledge that I will encourage the pursuit of knowledge in its pure as well as in its applied aspects, and this with Government support whenever Government support is clearly necessary and appropriate. The case of atomic energy is in point.

● **Atomic potential**—In putting the atom to work, we have been influenced more often by fear than by the thirst for knowledge. We have allowed the great developments of the peaceful uses of nuclear explosives to languish in the vain hope of finding some permanent and reliable accommodation with the Soviet Union. It has become amply evident that great enterprises such as the digging of a sea-level canal across the American Isthmus are now technically feasible. At a limited cost, this enterprise could provide a great waterway capable of carrying increasing traffic for decades to come from ocean to ocean. It would facilitate transportation in the Western Hemisphere and contribute importantly to our strength and the reduction of our vulnerability.

There are many such tasks to be done in the United States and in other parts of the world where development is badly needed. The peaceful use of the magnificent tools given us by atomic energy can also make accessible deep-lying mineral resources. We need not worry about the scarcity of raw materials if we make intelligent use of the instruments which our scientists have developed and will continue to develop.

There are at least two watchwords in science. One is progress, the other is cooperation. We have too often neglected the possibility of cooperating with our own great industrial enterprises. We have much too frequently misdirected cooperation with other countries. Consider, for instance, the possibility that in the near future the cost of purifying sea water can be reduced to the point where it is economically feasible so that it can be used for the support of the livelihood of unborn millions. But we need not try to achieve this goal—as the Administration has announced—in cooperation with the Soviet rulers who have demonstrated time after time that they will not give to a joint enterprise their honest and unselfish efforts. Instead, we can and we should share our efforts with the free nations just as we share with them our historic past, our ideals and our hopes for a better future.

Science and technology are not only the firm foundation of our future strength. They are also a bridge which links people of different countries and different tongues. Let this bridge unite those who wish to understand each other in an honest manner. Let it contribute to our great efforts which will make our Nation both secure and free, and the whole Earth a better place on which to live.

NASA Seeks Scientist-Astronauts

TEN TO TWENTY scientists will be selected next spring to join the U.S. astronaut corps for future manned spaceflights.

NASA announced that recruiting has already begun and a Dec. 31, 1964, deadline has been set for receipt of applications.

The space agency's action is expected to silence a long-standing complaint from the U.S. scientific community that no scientists or engineers are in the current corps of 29 astronauts.

NASA apparently still has not agreed to another demand of the scientific community—that a scientist go along on the first U.S. manned lunar landing. A spokesman said it is not expected that any of the 10 to 20 men to be selected will make the first flight.

The Soviet Union announced earlier this year that a physician will accompany all future cosmonauts during its spaceflight program. Both a scientist and a physician were included in the crew of the three-man *Voskhod* spacecraft flight on Oct. 12-13, 1964.

The space agency said its new program will be open to members of the medical, scientific or engineering professions or any combination of those specialties.

In addition to fulfilling seven qualifications established by NASA's Office of Space Sciences and the National Academy of Sciences, certain applicants, after preliminary screening, will be asked to submit additional material including published or unpublished scientific and engineering reports, and essays on field experience, research activities and individual thoughts on scientific objectives for manned missions in space.

Selected astronauts who are not already pilots will be trained to qualify as pilots of high-performance aircraft or helicopters.

In order to be eligible for the program, an applicant must:

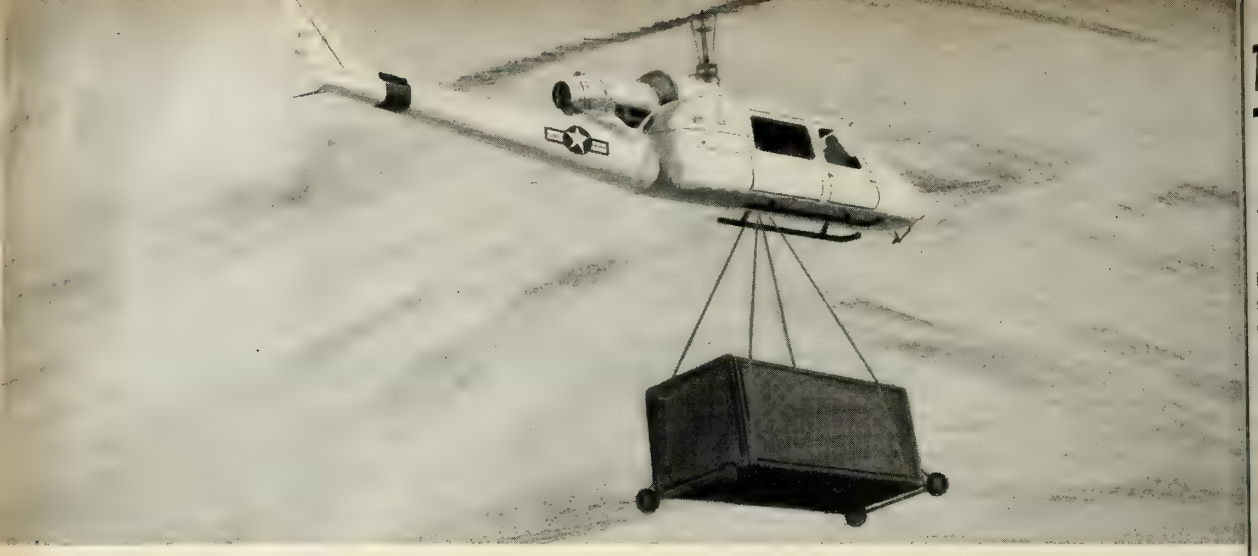
- Have been born on or after Aug. 1, 1930; be a citizen of the United States; and be no taller than six feet.
- Have a bachelor's degree and a doctorate in the natural sciences, medicine or engineering, or the equivalent in experience.
- Have transcripts of academic records sent directly to Scientist-Astronaut, P.O. Box 2201, Houston, Tex., 77058, from all institutions of higher education which he has attended.
- Have scores in the graduate record examinations sent by Educational Testing Service, Princeton, N.J., directly to Scientist-Astronaut at the Houston address. (NOTE: Examinations will be given Jan. 16, 1965. Completed application and examination fee must reach Educational Testing Service by Dec. 31, 1964. In the event that an applicant has not taken graduate record examinations and plans to take the Jan. 16 examination, he should note on his application that scores from that examination will be forwarded directly to Scientist-Astronaut, Houston, by the Educational Testing Service.)
- Submit a Standard Form 57, Federal Employment Application Form, available at any U.S. Post Office.
- Submit a Standard Form 89, Report of Medical History, obtainable at any U.S. Post Office. This form should be signed by both the applicant and his physician.
- Submit Standard Form 78, Certificate of Medical Examination, Part A to be completed by applicant and Part B, Questions 1 through 21, to be completed by his physician. This form also is available at local post offices or offices of the Civil Service Commission.

All applicants should address their applications, postmarked no later than midnight, Dec. 31, 1964, to Scientist-Astronaut, P.O. Box 2201, Houston, Tex. 77058. ■

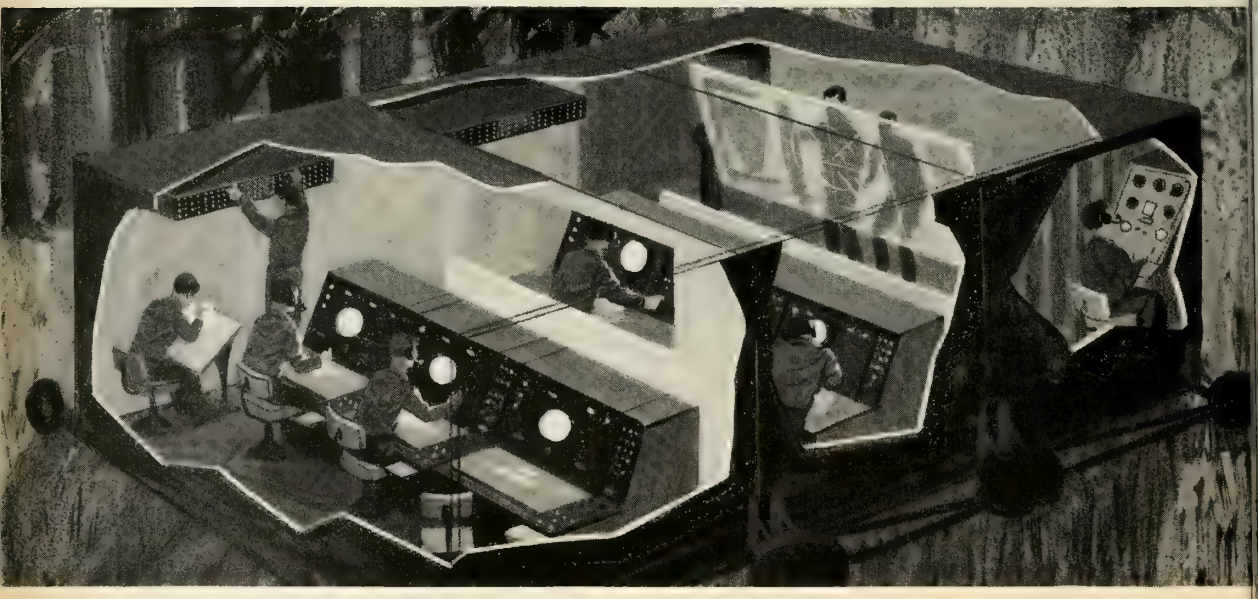


First Complete Gemini Readied for Titan

TWO-MAN Gemini spacecraft, first fully equipped model, is raised into service tower over its Titan II launch vehicle at Cape Kennedy. McDonnell capsule and Martin Co. booster are due for final unmanned launch later this year.



Deliver 3 Westinghouse mobile huts like this—



and you have a complete radar operations center

Until now, tactical operations centers have been large and unwieldy complexes. Time-consuming assembly and low intercept capacity have resulted in limited capability.

A new Westinghouse concept has changed the picture. The Westinghouse Mobile Radar Operations Center is a modular, pre-wired and pre-assembled system that adapts to the mission requirements. A basic three-hut configuration can be transported in a single C-130 and can be placed in operation in 20 minutes or less. To adapt to changing tactical situations, modules may be added or substracted. All huts are easily transportable over terrain on standard vehicles or with mobilizers.

The addition of DIGITRAC—an optional Westinghouse digital weapons control system—is a major aid to the weapons controller. DIGITRAC greatly increases capacity and accuracy in the control of tactical interceptors. The DIGITRAC control system can also provide highly mobile, ground-based guidance for close support, interdiction, resupply and air traffic control.

For complete information on the Westinghouse Mobile Radar Operations Center, write for Bulletin SD-1-1-4. Westinghouse Electric Corporation, P.O. Box 868, Pittsburgh, Pennsylvania 15230. J-02359

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Technical Countdown

ELECTRONICS

10,000-ft. Orbiting Antenna Feasible

While at least four 100-ft. gravity gradient booms of beryllium-copper have been flown successfully in *Transit* satellites, manufacturer of the booms, DeHavilland Aircraft of Canada, believes that use of 10,000-ft.-long booms is also quite feasible. An 850-ft. antenna has already been delivered. This takes 2½ hours to extend and has a packaged weight of about 15 lbs. Two 5,000-ft. booms, for a dipole antenna, would weigh about 125 lbs. and require a 15-lb. extension mechanism.

AF Ups Amplifier Tube Power Output

Combining pairs of traveling wave amplifiers will allow much higher peak powers, limited only by other components in the system. Merton C. Kraft, an engineer with the Rome Air Development Center, Griffiss AFB, has combined the power output of two high-power C-band traveling wave amplifiers producing eight megawatts of peak power. Kraft used a newly-developed traveling wave tube providing an output power of more than four megawatts over a frequency band 500 mc wide. The electronic expert effectively paralleled output of two tubes in a short-slot 3-db hybrid coupler. Kraft discovered that the frequency and amplitude of each source must be identical to provide a high combining efficiency.

Radar Docking After Rendezvous Demonstrated

Full-scale tests made by Martin Marietta of the use of radar during the docking phase of rendezvous have shown that in 59 automatically controlled runs all contacts fell within a 0.5-in. radius circle. The radar, developed by Raytheon Co., operates through rendezvous all the way to contact. It is a 10,000 mc CW doppler solid-state system, operating with an active transponder. These new results open fresh possibilities, such as the automatic rendezvous of unmanned resupply vehicles with a space station.

Spacecraft Air Density Meter in Offing

A system for measuring air density at altitudes between 400,000 ft. and 1,000,000 ft., using a laser beam, is being developed by Litton Industries. Aim is to present an astronaut with useful information for the manual control of a spacecraft. Principle applied is to measure light back-scattered when a multi-megawatt laser beam is fired from the spacecraft. Current work at Litton is concentrating on getting laser second-harmonic output from ADP crystals to obtain the bonus in back-scatter that increased frequency brings. Work is also under way on saturated filters as a lightweight replacement for the motor used for Q-switching the giant pulse laser.

Telemetry Near the Sun

Studies by General Electric space sciences laboratory show that microwave telemetry transmission from solar probes will not be adversely affected when the probe is outside two degrees of the Earth-Sun radius (eight solar radii). Transmission through the solar corona extending out to 25 solar radii is only slightly attentuated by angular scattering. But communication will be interrupted when a solar flare injects masses of ionized gas into the transmission path.

Thin-Film Micro-Computer Nears Completion

A microelectronic computer with a thin-film memory, suitable for spacecraft use, is nearing completion at Control Data Corp. A company-sponsored development, the miniature computer needs no cooling and can be opened like a book while remaining in operation.

New IF Amplifier Developed

A 60-mc radar transponder IF amplifier made up of microelectronic modules has been developed by the military electronics division of Motorola Inc. Eight integrated circuit modules of four different types are used: an input matching network, four standard amplifiers, three interstage filters, and a detector. The standard amplifier is a 20-db gain basic building block containing no tuning elements. Small toroidal coils 50 mils in diameter are used in the interstage filters.

SPACE SUPPORT

ELDO Down-Range Station Detailed

Design of the down-range tracking and command station for the European Launcher Development Organization (ELDO) is intended to meet a mission requirement of a 300-n.-mi. orbit with eccentricity less than 0.002. Located in Arnhem Land, Australia, the station will have a transmitted power of 10 kw at 1427-9 mc.

GUIDANCE

Torpedo System at Lear

For an advanced torpedo guidance system, Lear Siegler's instrument division is producing a rate package consisting of three Series 7601 "Talisman" gyros and three minature accelerometers. The 6.5-oz. Talisman, 1 in. in diameter and 2⅝ in. long, is one of the smallest units to go into volume production. Fluid damping is provided, with automatic temperature correction.

SPACE SCIENCE

Topsi Reports on Ionosphere

The topside sounder satellite launched Aug. 25 (*Explorer XX*) is providing new information on the arrangement of ionospheric irregularities and on the structure of plasma resonances, report scientists at the Central Radio Propagation Laboratory, National Bureau of Standards. Both "scatter spread F" and "ducted spread F" have been observed. Both appear to be caused by irregularities arranged in sheets. Interference patterns have been observed in ionic resonances and are attributed to standing wave patterns that change with satellite attitude.

Dielectric Camera for Metsat

A pre-prototype of a dielectric camera for a meteorological satellite has been developed by RCA, under contract from NASA Goddard. It uses 100 ft. of 35-mm dielectric tape for image storage. Because medium-resolution pictures with wide-angle (100°) coverage are called for, the optics include a scanning mirror that spreads the image along the moving tape. Image format is 0.726 in. wide x 8.56 in. long. During readout, the electron beam scanning density of 857 lines per inch results in an output band width of 640 kc.

Here are a few of the things Northrop does:



Makes U.S. Army's only operational surveillance drone, the camera-carrying SD-1.



Developed earth sensor for Ranger lunar vehicle.



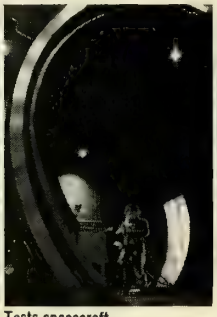
Uses nuclear reactor to determine effects of space radiation on men and equipment.



Makes metal architectural components for homes, factories, commercial and public buildings.



Provides recovery systems for Apollo and all manned space vehicles.



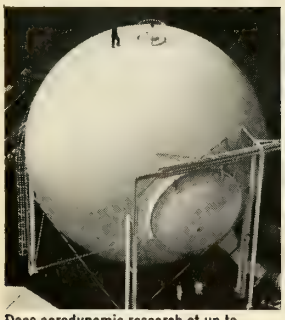
Tests spacecraft systems in man-rated environmental chamber.



Builds F-5 supersonic tactical fighters for America's allies.



Makes Datico prelaunch checkout systems for Polaris missiles in nuclear subs.



Does aerodynamic research at up to 14 times the speed of sound in hypersonic wind tunnel.



Studies problems of human beings living and working in space.



Designs and builds worldwide communications systems.



Squeezes minerals and gases at million-pound pressures to unlock secrets of the solar system.



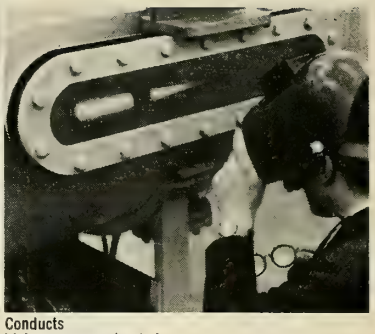
eveloped stereometric comparison
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terpretation of aerial photographs.



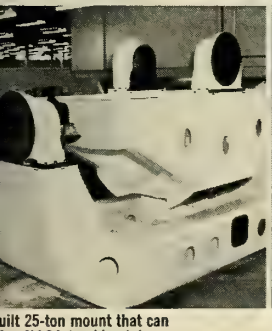
Builds T-38
supersonic trainers
for USAF.



Designs
vehicles to roam
the moon.



Conducts
high-energy accelerated
plasma studies.



uilt 25-ton mount that can
ign NASA tracking telescope
ithin 2 seconds of arc.



Develops tiny air-
and space-borne computers
with gigantic capacity.



Conducts Laminar Flow Control
research that may double the range and
endurance of large aircraft.



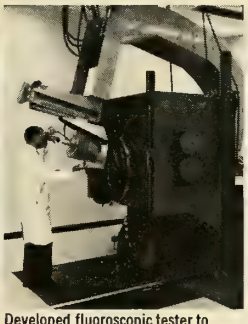
Uses Flash X-Ray to
study effects of nuclear bursts on
electronic systems.



eveloped low-profile ring
tennas to replace towers and whips in
mmunications systems.



Manufactures ultra-high-precision
subminiature gyroscopes for
guidance and control systems.



Developed fluoroscopic tester to
examine aerospace components
under extreme flight conditions.



Developed NV-101
autogyro utility drone for
many military uses.

Northrop scientists and engineers are at work on more than 80 important projects and programs in environments that range from the depths of the sea to the outer reaches of interplanetary space.

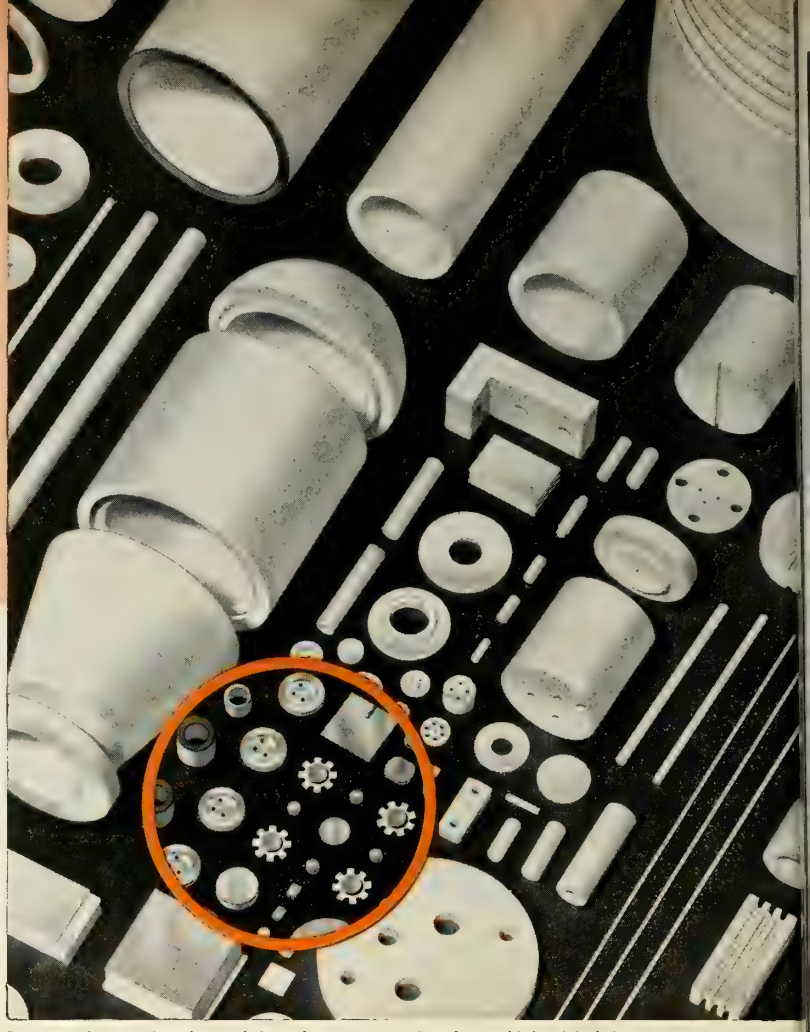
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PROGRESS REPORT

AlSiMag® BERYLLIA CERAMICS

- high thermal conductivity
- high reliability
- excellent electrical insulator
- low losses
- high performance in micro-miniatures



Parts in circle approximately actual size, other parts approximately two-thirds original size.

Almost two years ago a new, separate, fully integrated facility for AlSiMag Beryllia Ceramics was brought into production. All AlSiMag BeO ceramics are produced in one organization, one plant, one responsibility . . . from raw material preparation through precision grinding, glazing, and metallizing. This single responsibility permits close control and high reliability.

PRECISION plus HIGH RELIABILITY are the principal reasons for accelerated growth in the use of AlSiMag beryllias.

Without grinding, critical dimensions usually can be held within dimensional tolerances normally associated with fine metal work. Thus a wide range of designs, difficult or prohibitively expensive to grind, are now practical. It also permits AlSiMag production in volume not possible under the sinter and grind procedures. In some instances the natural ceramic surface has more desirable characteristics than a lapped surface. Where an exceptionally smooth surface is required, such as in thin film circuitry, a special AlSiMag glaze closely parallels thermal expansion characteristics of the ceramic substrate.

Production of small AlSiMag beryllia ceramics in volume to close tolerances has been valuable in micro circuitry and where high reliability is important.

Good progress has been made on precision metallizing to permit hermetic seals.

The "no-fire capabilities" of BeO help in certain missile-ordnance applications.

Spacers, washers or blocks of AlSiMag BeO conduct heat away from sensitive devices, are smaller, lighter, cheaper, and more reliable than fans or blowers.

For thermocouple applications, AlSiMag BeO ceramics are furnished either as dense tubes or as crushable materials.

Advances in manufacturing capabilities lead to increased uses as heat sinks, substrates, micro-wave guides and windows, resistor cores, envelopes and semiconductor packages. Metallization and glazing techniques developed by AlSiMag are important in envelope and package designs with strong hermetic seals and high thermal conductivity.

All AlSiMag beryllia parts are carefully cleaned, packaged and labeled to permit appropriate handling on arrival. No-charge samples are generally not available in AlSiMag beryllia ceramics. Prototype orders are supplied to your specifications promptly and at a definite price.

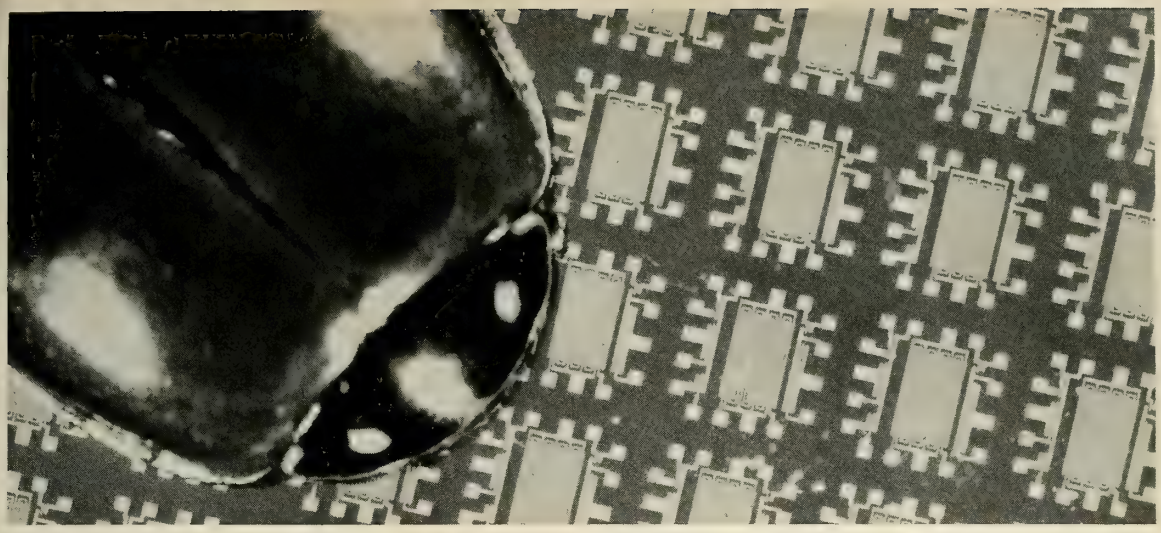
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63rd YEAR OF CERAMIC LEADERSHIP



CIRCUIT PATTERNS, each containing six transistors, are contrasted in size with a ladybug.

space electronics

Autonetics Expects 20-cu.-in. Digital Computer To Be Ready in 3-4 Years

Production of micropower IC's, registered bonding and use of single-crystal ferrite sandwich memories aid development

by Rex Pay

ANAHEIM, CALIF.—Autonetics expects to have squeezed down the size of a digital computer to 20 cu. in. within the next three to four years. This represents a 56:1 reduction in size compared with the North American Aviation, Inc., division's current Monica 26C integrated circuit computer, intended for missile and spacecraft use.

Describing the aims of the research and development program, Vice President Cedric O'Donnell said three techniques would contribute to future size reduction: production of micropower integrated circuits, registered bonding (a version of the "flip-chip" technique), and use of single-crystal ferrite sandwich memories.

He announced the development of single-crystal field-effect transistors, deposited on a sapphire base, and fabrication of a general-purpose thin-film amplifier using these devices.

● **Lead time**—In three to four years, he said, Autonetics could have the first model of a computer embodying the new techniques. A machine with an 8,-192-word (20-bit) main memory and 256-word scratch-pad memory would weigh 3.5 lbs. and consume 8 watts of power. These figures represent 26:1 and 24:1 reductions compared to the Monica 26C, respectively.

O'Donnell predicted that the new techniques would reduce computer costs and make feasible machines of an order of magnitude larger and faster than STRETCH.

Autonetics research into micropower circuits centers on the use of heteroepitaxial techniques—the growth of one single crystal material on top of another. Single crystal silicon has been grown both on polycrystalline silicon and on sapphire. Other types of crystal, tungsten for example, have also been grown on sapphire and this looks like the base material that is receiving closest attention.

Because of the large number of devices deposited on a sapphire substrate, the cost of the substrate itself is not considered expensive. With suitable depositions, a wide range of electrical parameters can be produced. Aim would be to deposit different types of single-crystal material on the same sapphire base.

Silicon dioxide would be used as an insulator, tantalum oxide or titanium as dielectrics, tantalum-chromium-nickel as a conductor, silicon or gallium arsenide as active devices, cadmium sulfide or zinc telluride as photosensors, niobium-tin as a superconductor, and manganese ferrite for ferromagnetic devices.

Autonetics now has a horizontal epitaxial reactor that takes 60 slices. As yet, gallium arsenide has not been grown in single crystal form on sapphire.

● **Materials preparation stressed**—

Discussing Autonetics work in heteroepitaxy, Dr. Arnold Miller, physical research director, said that keys to success were substrate selection and orientation, correct surface pretreatment, and control of surface interlayer formation.

Since the announcement of growth of single-crystal silicon growth on sapphire in July, 1963, subsequent work has shown that there is a great deal more flexibility in the technique than was originally suspected. There are 13 orientations of sapphire that give four modes of growth. Three of these give 111 silicon, one gives 100 silicon.

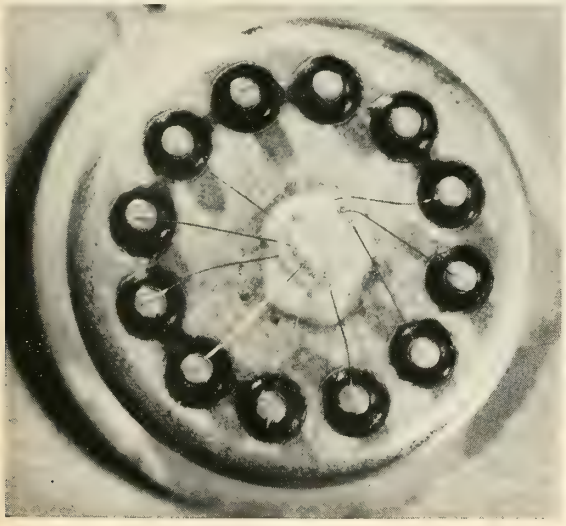
On-going research aims at reducing dislocations and twinning densities and at examining circuit applications. Studies emphasize meeting special circuit requirements that cannot be met by current bulk integrated circuits and also tying in the electronic devices with other devices on a single substrate. One possibility for the future is a steerable active radar array using gallium arsenide.

Principal active device being produced on a sapphire substrate at Autonetics is a thin-film field-effect transistor. This is a single-crystal device that Robert Downing, chief of device research, claimed was more stable than polycrystalline devices. He said it would operate at temperatures up to 250°C. Film thickness amounts to 0.5 or 1.0 micron.

● **Amplifier size reduced**—An integrated circuit-improvement program at the research laboratories has led to production of a 1-mc bandwidth general-purpose amplifier of the *Minuteman II* type in thin-film form. This shows a 4:1 reduction in size compared to the bulk-diffused device. Thin-film resistors provide higher accuracy and stability. Excellent radiation resistance is claimed and operating temperature range is doubled compared with the diffused circuit.

The thin-film circuit contains 17 field-effect transistors and seven 5-kilohm nichrome resistors. In comparison, the bulk-diffused device has five transistors, four diodes, and seven resistors.

An advantage of the thin-film technique, said Downing, is that the circuit designer can specify the parameters he requires of the FET, to the extent of specifying the device length. The electronic sensor systems division of Autonetics is now designing circuits of this type. Typical device parameters are 2,000 micromhos transconductance, 2 pf input capacitance, dc input resistance greater than a million megohms, and an amplification factor of 20 to 30.



CHIP containing six thin-film insulated-gate field-effect transistors mounted for performance tests at NAA.

Channel length in the FET is 5-6 microns, with 100 angstroms thickness. Gate length can be varied from 0.2 in. to 0.001 in., with yield problems appearing at the lower limit.

● **How it's made**—The device is formed in an island of single crystal p-type silicon deposited on sapphire. A silicon dioxide mask is deposited over the intended gate region and a heavy N+ diffusion converts the silicon to N except for a small island under the gate. A narrow channel of N+ then exists between the P area and the silicon dioxide, on top of which is deposited the aluminum gate.

A somewhat similar technique is also being used at Autonetics to produce thin-film diodes and transistors. In these, the diffusion under the S_iO_2 mask is controlled to produce vertical P-N junctions.

Diodes with junction areas of one square micron have been produced in this way, yielding switching speeds beyond the 1½ nanosecond resolution of the measuring instrument. A diode with 25 square microns area switched in about one nanosecond. Possible UHF applications for devices produced by this fabrication technique are being studied.

Epitaxial films have also been grown at Autonetics by glow-discharge activation. The self-healing nature of this deposition process leads to pinhole-free films. Autonetics is currently developing a larger reactor for this program.

An integrated circuit amplifier formed by the polycrystalline isolation technique is being tested in a radar system at Autonetics in place of a vacuum-deposited thin-film amplifier with discrete active devices. The new amplifier has a flat response from 0-150 mc. Extension of this response to 1,000 mc is expected, using this technique.

● **Memory system refinements**—Work on memory systems at Autonetics has also led to the growth of single-crystal epitaxial ferrite on a magnesia base. Conductor lines 2-3 mils wide can be pre-deposited on the magnesia and the ferrite crystal can be grown on top of these and around an array of 2-3 mil gold wires suspended over the magnesia.

The result is a memory unit about 15-20 mils thick with an information density of 10,000 bits per square inch. Thirty of these planes would provide a 30-bit word memory in a fraction of a cubic inch.

A non-destructive readout memory of this type is said to be economical to fabricate and compatible with integrated circuits. With currents of 30 ma. readout rates of 10 mc can be obtained. Ultimately a packing density of 1 billion bits per cu. ft. could be obtained, but associated readout connections and power dissipation problems would be phenomenal.

For optical data-processing research, Autonetics has developed matrices of photodiodes on 0.01-in. centers. These can be used to measure the position of a light beam within a data processor. They can also be used to track a star background or a specified target.

Discussing Autonetics' present capability for precision diffusion of arrays of devices, O'Donnell said that Autonetics could mask, register, and diffuse with a total error of ±0.5 micron.

He said this suggested the possibility of a fixed readout memory with a packing density of 6 million bits per sq. in. Each bit would be represented by a photosensitive device and the information to be read out would be inserted by depositing an opaque pattern over the devices. Where the pattern obscured a device, an 0 would be represented. Readout would be obtained by illuminating the memory. ■

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Prototype ELDO Guidance Receiver To Be Delivered Next June

by Frank G. McGuire

ANTWERP, BELGIUM—Delivery of the complete guidance receiver system for the European Launcher Development Organizaton (ELDO) booster is slated for next June, and a contract has been awarded for initial work on an advanced system.

Bell Telephone Manufacturing Co. of Belgium, contractor for major portions of the ELDO guidance system, says its prototype of the receiver system is on schedule and delivery of the operational tracking trailer and computer trailer should be on schedule in June.

A contract naming BTM as prime contractor for study of the advanced ELDO guidance system has been let, after a competition including UK government laboratories, and engineering development for radio and inertial guidance systems will get underway early next year.

Considerable progress has been reported in the advanced ELDO system, for which the booster will use an uprated vehicle with the addition of an apogee stage for payloads to be placed in synchronous orbits. The injection phase of a synchronous satellite will be fully guided.

Accuracy of the initial system on orbital injection will be about 2 x 10^{-3} eccentricity for a reference task of a 300 n.m. circular polar orbit. One key to this hoped-for accuracy is the Control Data Corporation CDC 3200 real-time guidance computer chosen by ELDO.

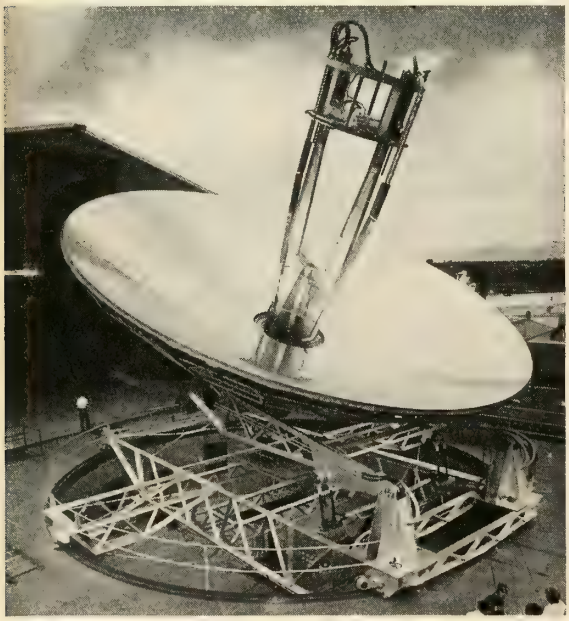
● **Guidance details**—In outlining ELDO guidance details for M/R here, Bell Telephone officials said communications satellite goals will demand such accuracies and an orbital deviation of ±10 n.m. is considered the maximum allowable. This corresponds to 10^{-3} accuracies with orbital injection velocities of 7 km/sec.

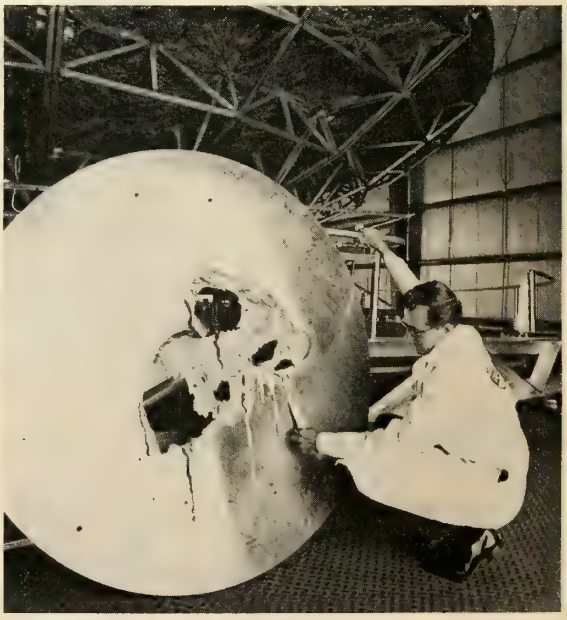
In the ELDO setup, Belgium is responsible for development, supply and installation of downrange guidance to be based in northern Australia (404 miles east of Darwin) for guidance of launchings northward from Woomera.

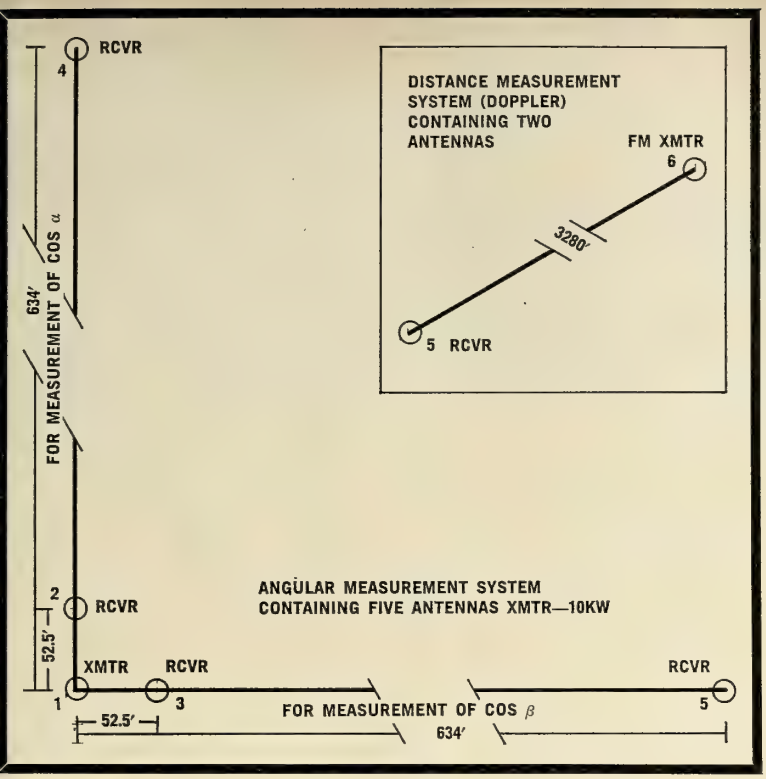
System engineering for the nation's effort is in the hands of Manufacture Belge de Lampes et de Materiel Electronique (MBLE), while BTM handles receiver equipment and Ateliers de Construction Electrique de Charleroi (ACEC) handles the transponder and

Solar Concentrator Demonstrates its Prowess

LEFT: Elaborate framework that allows this 45-ft.-dia. solar concentrator to track the Sun from horizon to horizon is shown by program manager, Sundstrand Aviation, Denver. Built by Goodyear Aerospace for Sundstrand, concentrator is part of facility to be used with AF dynamic energy conversion program. RIGHT: Five-foot aluminum disc melted in seconds after being exposed to solar rays reflected from solar concentrator, which appears in background of three-story sliding building.







ELDO GUIDANCE short baseline interferometer system.

ground transmitter. In addition to its system engineering role, MBLE builds aerials, auto-tracking-slaving and parametric amplifiers.

Basically, the present system consists of an advanced 1,600 mc CW radar system, comprising a short-baseline (200 meters) interferometer with six antennas for coordination of data, the CDC 3200 real-time guidance computer, a command link and a vehicle-borne guidance transponder.

Henri Gustin, BTM project engineer, said his company is directly responsible for advanced receiving technique studies (threshold depression involving coherent detection and phase-lock/FM feedback loops). The firm is also responsible for engineering design and manufacture of the AME/DME radar receivers, range and angular ambiguity resolvers and digitizers, command link modulators, frequency synthesizers with associated frequency and time correlation, station internal communications, overall system simulation, transportable equipment housing facilities and procurement of the guidance computer.

Both U.S.-made FPS-16 and FPO-6 radars were evaluated for the ELDO mission, as was the French-made Aquitan system, but these were rejected on various grounds, including the 75-kw peak-pulse transponder power required, inadequate accuracy and logistic problems.

Performance of the short-baseline interferometer (SBI) system is 0.1 milliradians angular, ±100 meters altitude, and ±5m/sec velocity. The five antennas are steerable on both X and Y axes in a 140-ft. radius.

A security factor in the signal-to-noise ratio of 20 db in each up-and-down channel has been adopted as a design basis.

Accurate determination of the vehicle's position for the issuance of guidance commands requires determination of two angles and the slant range. The angles are measured by two interferometers, comprised of three antennas at the apexes of right triangles. Measurement of the differential in arrival times of the transponder signal at each antenna is carried out by feeding the phase difference into a computer, already armed with the comparative figure of the distance between the antennas.

After the computer calculates the angles by comparing the phase differential with the baseline of the interferometer, and after the slant range has been determined by transmission of a signal to the vehicle and a reply is received for time-delay measurements, guidance commands are sent via the ground-vehicle command link. The slant-range transponder is a 200-mw unit.

The vehicle's velocity, consisting of a radial and two tangential components, is thus measured by the described Doppler DME unit for the first component and for the second component by an interferometer having a longer baseline than that used for angular measurements.

The downrange station is designed with six parabolic antennas, with five being followed by receivers. The 165.5-in.-dia. units are covered by 33-ft. radomes, with antennas 1, 2 and 3 forming the interferometer for angles, with a base of 52.5 ft. Antennas 4 and 5 are the interferometer for tangential velocities, having a 634-ft. baseline. Slant range is determined by antennas 5 and 6, with the former having the additional function of measuring radial velocity and the latter having the additional function of sending command signals.

Antenna 5 is the auto-tracking unit, and the others are slaved to it. This unit is equipped with three parametric amplifiers, while the others have one.

Pre-operational checkout and calibration will use an airplane carrying a transmitter and operating on frequencies between 1427 and 1429 mc for the up-channel and 1525 to 1540 mc down-channel. The FM transmitter (#6) is designed to operate at 125 cps, 2 kc and 32 kc at about 10 kw power. It will be operated over 3,000 ft. from the interferometer complex to prevent interference.

● **Computer functions**—The CDC 3200 unit will locate the vehicle, using data gained from the antennas, determine the correct guidance commands, predict injection time, determine antenna control commands, transmit guidance commands, and store data, including all measurements and corrected trajectories.

The computer can operate either by calculating new parameters directly from received data, or by determining necessary corrections through a comparison of received and pre-calculated data.

The computer is an off-the-shelf unit previously described in MISSILES AND ROCKETS (Feb. 17, p. 21) and having an 8,000-word memory at 24 bits per word, capable of comparing the actual vs. planned trajectory at intervals of 100 milliseconds.

"It's not the purpose of ELDO to develop new equipment specifically for this purpose," Gustin told M/R, "so we compared many models of commercial equipment to get the best unit available. With a very slight modification for our purposes, the CDC 3200 should be ideal."

He added that the only modification BTM has in mind for the computer is a re-programming of the unit. ■

Paper on Intellectronics Highlight for 25,000 At NEC Exhibition

by Charles D. LaFond

CHICAGO—Studies in the field of psychical research will someday lead to a new era in the information and communications sciences, predicted Dr. Henry K. Puharich here last week at the 20th Annual National Electronics Conference and Exhibition.

Drawing a steady parallel between the human mind and present-day electronic data processing systems, Puharich discussed scientific efforts underway to determine the number and kinds of actual information channels allocated to the brain. Puharich, whose experimental research and writings have often proven controversial among his contemporaries, is the president and medical research director of Intelectron Corp. in New York.

The science of the intellect, which includes logic, mathematics, and accoustics, said Puharich, can be called intellectronics and its processes intellection. A primary goal of intellectronics is to establish the total number of information channels available to the brain. Classical senses of vision, audition, smell, taste, and touch, he declared, are only first approximations. Others readily apparent include the ability to perceive acceleration, vibration, pressure, temperature change or heat, and pain.

Directly interrelated with intellectronics is the science of genetics, which inherently involves vast complex programming. To crack the secret of this program, Puharich asserted, will be to understand the very nature of the mind itself.

● **NEC follows trend**—Conference officials expressed satisfaction with this year's more than 400 exhibits, even though the total, following a national trend, was some 20% below last year's count. Both the exhibition and technical program were held in Chicago's new McCormick Place during the three-day conference (Oct. 19-21).

Displays generally centered on semiconductors and advanced solid-state circuits, small electronic instruments, and electronics manufacturing equipment. Exhibitors, in general, reported good booth attendance and both sales interest and early sales response to their wares.

An attendance of 25,000 anticipated by NEC officials appeared optimistic. Registration figures were not made available to the press, but the concensus was that total registration through Wednesday would fall far short of last year's figure of 25,000.

Well over 200 papers were presented at the technical sessions. A highlight of the conference was the increased use of the industrial seminar. Eleven such meetings were held by various manufacturers, largely in the fields of semiconductors, communications and computer technology. Texas Instruments, Inc., and Motorola, Inc., provided a variety of different seminars each day of the meeting. General Electric and Siliconix, Inc., each held one half-day seminars.

Other sessions sponsored by the NEC included engineering refresher seminars in six specialized technical areas and four new-product seminars.

● **Puharich experiments**—Much of Dr. Puharich's present research effort is in finding a solution to permanent deafness, but the results of his company's work may provide fundamental knowledge applicable in many fields.

The human accepts acoustical inputs (analog), he stated, and converts these to data pulses (digital) for subsequent cerebral processing and understanding, but scientists still do not understand the encoding process, nor the conduction process, nor how the digital impulses give rise to particular "qualities" associated with the original sound input.

To study these processes, non-acoustic stimuli are being employed. In 1961, Allan Frey, Puharich pointed out, reported human cognition of low-energy pulse-modulated, 2-gc radar beams through an auditory sensation of "clicks."

This approach has been explored and confirmed by Intelectron's research, said Puharich. The question is, however, is RF response due to acoustic sense perception or is there a more direct effect on the brain?

Puharich's research team has tested 32 totally deaf subjects (those whose cochlea had been destroyed) using low-frequency, modulated RF energy as a "hearing" stimulus. All 32 subjects, claimed the scientist, ". . . experienced pure tone hearing, speech hearing, and music hearing." This he asserted, proves the existence of a modulated-RF-energy receiving channel in the human brain.

In addition, Puharich disclosed, his group has demonstrated a capability, using RF, to provide normal sensations of color and pattern.

He noted the curious fact that brain design is such (at least based on results of present testing) that it responds to frequencies regularly from 15 cps to 30 kc, but not to electromagnetic frequencies in the range from 30 kc to the infrared band. But, he predicted that means will be found in time to use most of the RF spectrum from 1 kc to 10^9 mc as data input sources directly to the brain.

Intelectron's recent experiments already have shown some frequency channels feasible for direct brain stimulation from 2 kc to 50 mc. Samplings at higher frequencies show the possibility of using discrete portions of the spectrum up to the visible light region. Further experimentation will clarify the potential, Puharich said.

● **Extraordinary manifestations**—Puharich then described briefly limited experiments using specially gifted subjects for though transfer. A "receiving" subject, placed in an anachoic chamber has successfully demonstrated the existence of thought transfer—even with RF screening and over distances up to 200 miles.

Puharich pointed out that so far there is no knowledge of the carrier system involved, its modulation, or the brain channel used for perception.

Also associated with the problem is the mystery of prediction and precognition by some individuals.

"Eventually we shall find a clarification of the principle of equivalence between mind and matter. I believe the day will come when it will be possible to formulate a legitimate relationship between mind and matter-energy. It is the search for this relationship—an equivalence, if you please—that will form one of the most exciting scientific quests in the decades to come," Puharich noted. ■

Lunar Orbiter Up for Design Review To Meet Delivery Date in Mid-'65

by Michael Getler

HAMPTON, VA.—First major spacecraft design review for the NASA-Langley/Boeing Co. *Lunar Orbiter,* scheduled to begin later this month at Boeing's Seattle facility, will reflect early changes in vehicle structure, engine mounting, tankage, and electronics which have reduced weight and are expected to increase reliability.

No changes have been made thus far in the lunar surface photographic craft's basic mission or concept. But a round of critical subsystem design reviews, and tests with thermal and dynamic test models and an engineering mock-up, have already led to the following improvements:

—The main 100-lb.-thrust engine for *Lunar Orbiter* will be gimballed rather than held in a fixed position as originally planned. With a fixed engine, the thrust vector did not pass through the vehicle center-of-gravity; a set of four 1-lb.-thrust engines was located on the solar panels to maintain vehicle stability and thrust alignment during main engine burn. Project engineers point out that use of a gimballed engine has improved fuel-use efficiency, removed some piping and—most importantly—removed the small thrusters, which were causing solar panel warping problems. Though the new mount requires a gimbal and some actuators, engineers say they have achieved a weight saving.

—The engine and the eight (.05-lb.-thrust) reaction control system (RCS) jets have been modularized and moved to the top of the spacecraft structure, so that they can be easily removed and tested as an entity. Also, the two outboard nitrogen tanks included in the original design have been removed and replaced by a single tank located inboard of the main structure; this will both pressurize the engine fuel and oxidizer system and provide high-pressure nitrogen for the cold-gas RCS. Combined gimballed engine and tankage reduction saved about 15 lbs. Another minor structural change involves replacement of the truss-type construction in the payload area with horseshoe-type beams which have added rigidity and eased emplacement of the photographic subsystem.

—In the electronics area, project scientists told MISSILES AND ROCKETS that integrated circuits will now be used in the digital programmer, replacing the discrete devices originally called for. The circuits will be Fairchild DTL types; this will save another 15 lbs., halving the weight of the original unit.

● **Production schedule**—Design reviews of major subsystems and spacecraft structure are expected to be continued until about January, 1965, and the first of eight spacecraft that Boeing will produce is expected to be available by mid-1965. The first three spacecraft will be used solely for ground test, and the remaining five for flight, although the vehicles are being built almost in parallel.

Spacecraft No. 4, the first flight vehicle, is expected to be available in early 1966, and the first launch is now set for mid-1966. Though there are two launch "windows" for *Lunar Orbiter* every month, project engineers say it is likely launchings of all five flight versions will be spaced within a one-year period.

Cost of the program is estimated at about $100 million, with about $80 million going to Boeing and its supporting contractors and $20 million for launch vehicles and mission support.

Results of the *Ranger VII* flight have not caused any change in the *Lunar Orbiter* design, according to Israel Taback, *Lunar Orbiter* spacecraft manager at the Langley Research Center here, but have served to verify the light intensities and photometric functions under which the design is proceeding.

Lunar Orbiter will be launched from Cape Kennedy aboard an *Atlas-Agena.* The launch, injection, and translunar trajectory are very similar to those used for *Ranger* and to be used for *Surveyor.* The major deviations from these flight plans result from launch-window constraints and lunar-orbit maneuvers dictated by the lighting and positioning required to fulfill the photographic mission and transmit data to Earth.

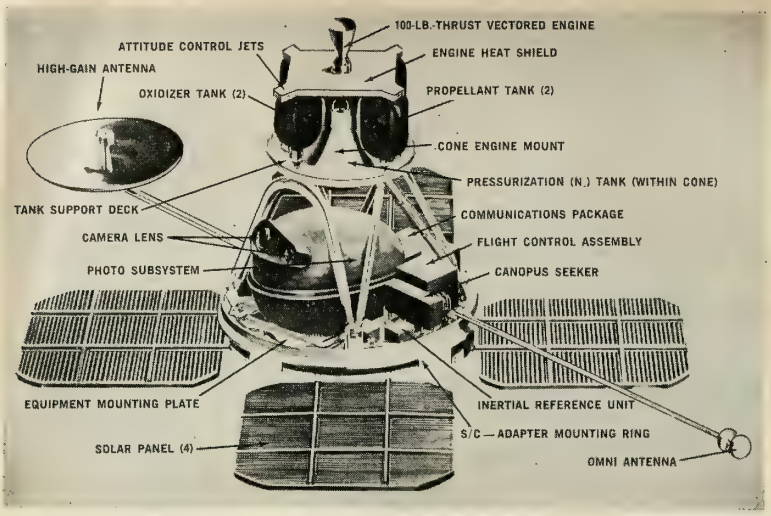
● **Proven equipment**—A major design goal of *Lunar Orbiter,* the use of space-proven hardware, is much in evidence in the design being finalized.

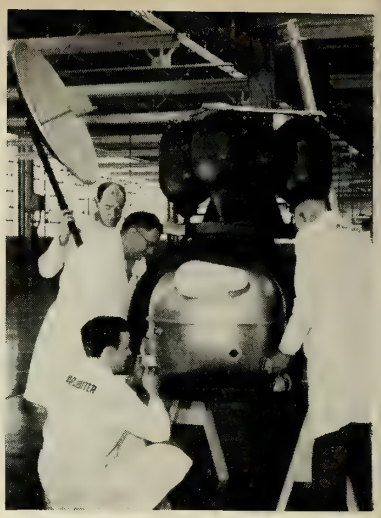
The 100-lb.-thrust hypergolic-fuel thruster being supplied by the Marquardt Corp., is the same engine being developed by the firm for the *LEM* RCS, where 16 of these devices are used. The engine will be used on *Orbiter* for mid-course corrections and deboost maneuvers, first into a 950-km lunar orbit and then into an elliptical orbit with a periselene of 46 km for the lunar photo mission.

Electrical subsystems associated with the solar cell/nickel-cadmium battery power system have all reportedly been developed or qualified in either the *Relay, Tiros,* or *Ranger* programs.

The camera system, being supplied by Eastman Kodak, is new; however, it is known that all of the major subsystems and some of the ground readout equipment have been used before, presumably aboard military reconnaissance satellites.

The guidance system is also similar to that used in *Mariner* and *Surveyor,* using Sun sensors and a Canopus-seeker for primary attitude reference and a strapped-down inertial package containing two gyros and an accelerometer for mid-course corrections and engine control during lunar orbital changes. ITT is supplying the star-tracker, an image dissector type using a CBS-Electronics tube. Sperry is supplying the inertial reference package. A contractor for the Sun sensors is expected to be selected within the next few weeks.





LEFT: Latest configuration of Lunar Orbiter reflects removal of outboard nitrogen tanks, modularization of engine and attitude-control jets at top of structure, and inclusion of horseshoe beams in payload area. Integrated circuits have also been okayed for use in the digital programmer. RIGHT: Mock-up of Lunar Orbiter is prepared for upcoming design review.

Boeing will supply the RCS, and will also provide a digital programmer for the spacecraft which will be capable of storing about 16 hours of digital command words in addition to real-time sequencing. Boeing will buy the magnetic-core memory for the sequencer.

Tankage for the spacecraft will be provided by Bell Aerospace Corp.

The communications subsystem, being supplied by RCA, includes high- and low-gain antennas, transponder, data conditioner, decoder, and programmer. The system will operate in conjunction with NASA's Deep Space Network, at S-band, putting out 10 watts via the directional high-gain antenna during video transmission and ½ watt when in a non-video mode via the low-gain antenna.

Since *Orbiter* is intended to be an operating contemporary of *Surveyor*, the two vehicles will each use three separate stations of the DSN for communications and tracking, allowing simultaneous communications with each craft with a minimum of interference. Video data bandwidth for transmission back to Earth will be about ¼ mc, with a SSB subcarrier used to phase-modulate the carrier. The system is expected to yield a 30 db S/N ratio, according to NASA scientists.

● **Mission plans**—*Lunar Orbiter's* primary mission is its photographic role in support of both *Surveyor* landing site selection and *LEM* landing site certification.

The 830-lb. spacecraft will also fulfill secondary non-photographic roles in support of *Apollo*, with gravitational field measurements taken via DSN tracking radars, and micrometeorite flux and high-energy particle flux measurements taken near the Moon with the same experimental package that was developed in-house by NASA for the *S-55 Explorer* satellite.

Another important on-board experiment will involve a pair of radiation dosage meters mounted on the cameras as an aid in analyzing radiation effects upon film and photography. RFP's for these devices are expected to be issued by Boeing in a few weeks.

To collect data useful to the lunar program, the satellite is being designed for a one-year lifetime, although its primary photographic function will only take about a month—roughly four days for transit and lunar-orbital maneuvers to place the lowest point of the orbit over the target area and to stabilize the orbit, about 15 days for actual picture-taking, and about 10 days for data-transmission to Earth.

The time to photograph is dictated by the launch window which provides maximum time over the area of interest (for *Apollo* the area surrounding the lunar equator bounded by $\pm$ 10 deg latitude and $\pm$ 60 deg longitude) at proper Sun angles for illumination (a Sun angle from above the horizon of between 15 and 40 degs is desirable). The transmit time is dictated by power demands which require the spacecraft to be in mutual visibility of the Sun (for the solar panels) and the Earth, an event which occurs roughly 46 minutes per orbit and which therefore requires about 10 days to transmit all the video the system is capable of recording. On-board data collection and transmission to Earth cannot be done simultaneously.

The rate at which the Moon moves around the Earth with respect to the Sun (12 degs per day) actually provides about a two-day launch window to get the proper illumination, giving planners some leeway and also making it possible to further extend the launch window somewhat by decreasing the Earth-Moon transit time.

● **Photo capabilities**—At the heart of the *Orbiter* payload is the two-lens Kodak system; a 24-in focal length, f/5.6 lens for high-resolution (1-meter) pictures from 46-km altitude above the lunar surface, and a Biogon 3-in f/4.5 lens for lower resolution (8 meters) but broader area coverage. The high-resolution lens produces a 60 x 219 mm film frame, equivalent to a 4.5 x 16.4 km area on the lunar surface from 46-km altitude. The low-resolution lens produces a 60 x 60 mm frame, corresponding to a 36 x 36 km surface area.

With 200 ft. of 70-mm Kodak SO 243 aerial film (reported to be highly resistant to radiation), this gives *Lunar Orbiter* a capability for photographing 40,000 sq km at 8 meters resolution and 8,000 sq km at 1-meter resolution. The 1-meter resolution is about 1,000 times better than that obtainable from Earth.

Within a 40,000 sq km area, NASA scientists point out, about 100 possible 20-km² potential landing sites for *Surveyor* can be viewed. Using the high-resolution mode, the on-board TV coverage provided by *Surveyor* can be extended from several hundred meters to a maximum of 80 x 80 km, locating navigational landmarks for *LEM* relative to proposed touchdown sites and picking out markers for intiation of lunar descent trajectories, which could be 90 deg in longitude from the intended landing area.

Coverage in each low-resolution

frame is overlapped 50% by the successive frame, so that, in effect, continuous stereo coverage at about 8 meters resolution is obtained over the entire 40,000-sq-km region of interest.

Simultaneously, the higher-resolution smaller-area frame is centered in each low-resolution frame, providing detailed samples of the area covered. NASA scientists stress that there are other modes in which the cameras could be operated to provide, for example, for continuous coverage using the higher-resolution lens and for greater coverage in the direction of flight rather than tangential to it. Numbers of frames taken per pass can be varied, and this allows deviation from prescribed filming to view other local areas of interest.

In general, NASA estimates show that by using a lunar orbital inclination of about 20 deg, any target in about half of the total equatorial area of interest for *Apollo* could be photographed on a single flight with a maximum waiting time of about 15 days. By keeping this orbital inclination to within about 1 deg, something NASA feels it can do, it can keep the orbit-to-orbit difference in path to about 15 km and ensure the desired camera coverage overlap.

Expressing *Orbiter* single-flight capabilities in another way, NASA engineers say the spacecraft could provide a continuous one-mile-wide coast-to-coast high-resolution photograph of the United States.

Exposed film aboard *Orbiter* is processed on-board with a Kodak Bi-mat processor at a speed of about 76 mm/minute, fast enough to process all the film taken on one orbit before a second pass is made. The on-board read-out system consists basically of a CBS line-scan tube used as a light source, a photomultiplier, and a video amplifier which conditions the signal for Earth transmission.

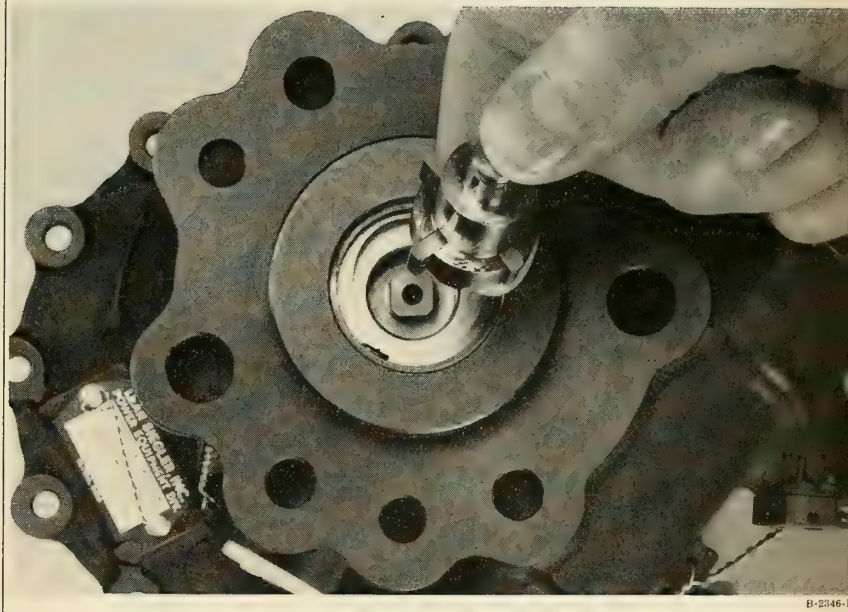
The ground reconstruction equipment, NASA says, displays the video data line-by-line on a kinescope face, and the image is recorded on a continuously moving 35-mm film strip. Each ground equipment has capability for two redundant recordings.

● **Incentive dividends**—The contract to Boeing for *Lunar Orbiter* earlier this year (M/R, Jan. 6, p. 13) marked the first use by Langley of an incentive contract for a large space program. NASA reports that it has resulted in "excellent attention by management both at Boeing and Langley not only to the technical aspects but also to costs."

The contract has incentives and penalties for cost, delivery, and performance. The first two are fairly easy to deal with, but the third is defined entirely on the basis of picture quality; thus far the only solution found has been to rely on a three-man NASA board to judge this performance. ■



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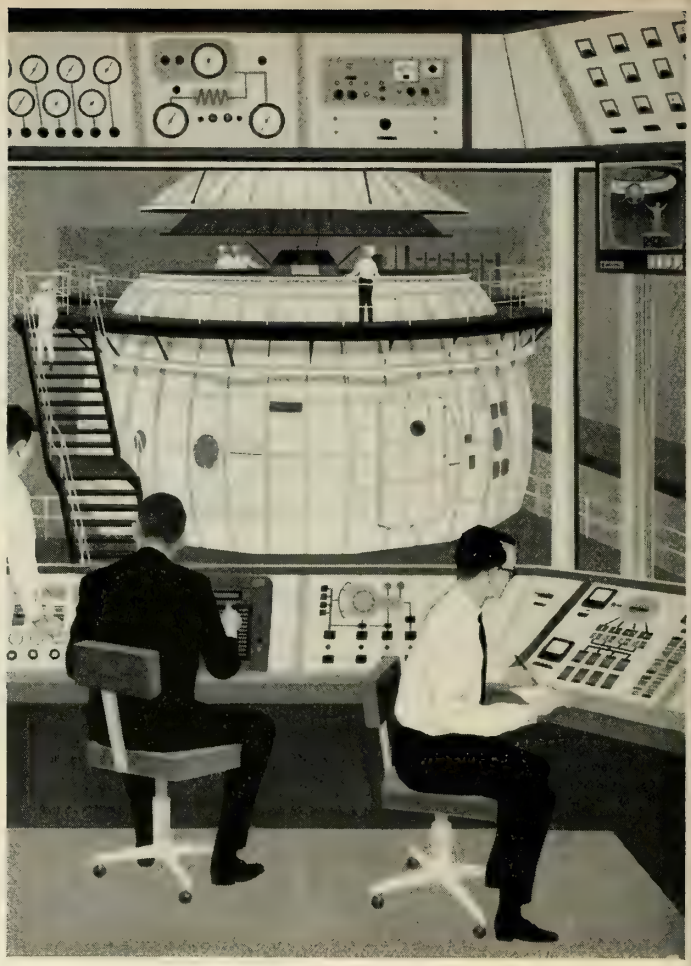
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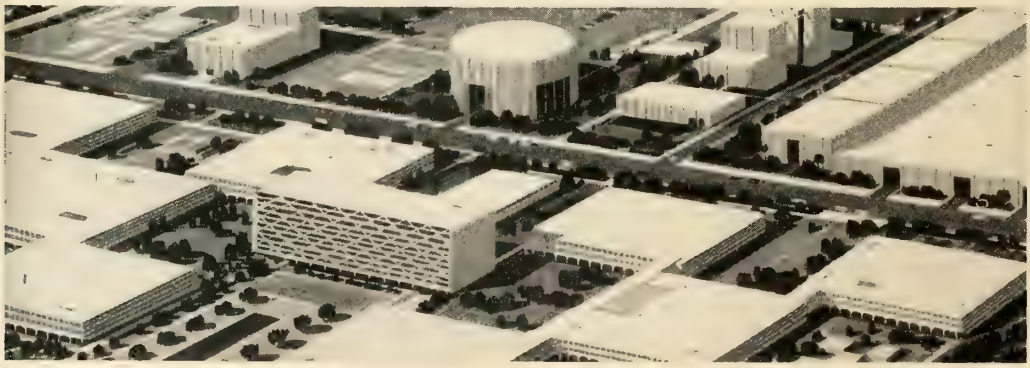
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Mergers and Acquisitions

Walter Kidde & Co., Inc., Belleville, N.J., has announced plans to acquire Associated Testing Laboratories, Inc., Wayne, N.J. The acquisition is to involve a trade of 10 shares of AL common for each 3.5 of Kidde. AL operates in the field of environmental and reliability testing for industry. The company also produces several lines of test chambers and laboratory equipment. . . . *Granger Assoc., Palo Alto, Calif., has acquired the product line and other assets of American Microwave and Television Corp., San Carlos, Calif. Amtel produces high resolution video systems for data transmission.* . . . Hewlett-Packard Co., Palo Alto, Calif., has entered negotiations with Delcon Corp. to make it a division of H-P. Delcon manufactures ultrasonic detection and test devices. H-P views the move as "a significant step in H-P's expansion into new fields of instrumentation."

Missile/Space Facilities

Bell Aerosystems Co. is negotiating with the state of New Mexico for 20,000 acres of land on which Bell intends to build a test complex for the development of advanced rocket engines using high-energy propellants. Only snag in the plan currently is that in order to provide the full 20,000 acres the state must swap 8,000-9,000 acres of land elsewhere with the Federal government. The New Mexico location was chosen after 131 possible sites in 18 states were considered. . . . *Maxson Electronics Corp., Great River, N.Y., has moved its Washington, D.C., office to new quarters, still in Washington. New address is 1101 17th St., N.W.* . . . Barnes Engineering Co., Stamford, Conn., designer and manufacturer of electro-optical instruments and systems for defense, space exploration and industry, has opened two new offices, one in Los Angeles and another in Santa Clara, Calif. . . . *Nelson-Ross Electronics, Inc., and its wholly owned subsidiary GNB, Inc., Hicksville, N.Y., have opened a new 4,000-sq.-ft. joint headquarters building in Hicksville. Nelson-Ross manufactures plug-in spectrum analyzers and accessory equipment; GNB, advanced modular laser energy systems and laser test instruments. The new facility houses complete engineering, production, marketing and administrative facilities for both companies.* . . . Communication Electronics, Inc., Rockville, Md., has moved its corporate headquarters to a new 50,000-sq.-ft. building in the Washington Science Center area in Rockville. CEI designs and produces special purpose radio-frequency receiving equipment for use in surveillance, telemetry, direction finding, counter-measures and general communications. The new building enables consolidation of all CEI activities under one roof. . . . *Westinghouse Electric Corp.'s Defense and Space Center has opened a new engineering center in Huntsville, Ala. The center is to provide coordinated engineering and marketing services in support of Westinghouse activities with the Army Missile Command and the George C. Marshall Space Flight Center.* . . . Bendix Field Engineering Corp., which recently received a three-year, $17-million contract to provide launch services for the Kennedy Space Center, has opened a personnel office in Titusville, Fla. . . . *Communications Satellite Corp. has moved its Washington, D.C., headquarters from 3029 Klingle Rd. to larger quarters at 1900 L St., N.W.* . . . Page Communications Engineers, Inc., Washington, D.C., has begun construction of a second building in Washington. Page designs, constructs, operates and maintains global telecommunications systems.

International

Fairchild Camera and Instrument Corp., Syosset, N.Y., has entered a licensing and know-how agreement with Elliott-Automation, Ltd., of London permitting E-A to use the Fairchild Planar process in the design and production of semiconductor devices, including use of integrated circuitry and thin-film techniques. . . . *Bell & Howell Co. has broken ground in Basingford, England, for a 21,000-sq.-ft. building to house offices and electronic instrumentation manufacturing facilities for the Consolidated Electrodynamics Div. of Bell & Howell, Ltd.* . . . Oak Electro/Netics Corp., Chrystal Lake, Ill., is converting its Hong Kong subsidiary to an assembler of VHF television tuners. An expanded plant will make possible the employment of 600 workers assembling tuners from parts fabricated in the United States. Full production is expected by mid-1965. . . . *IIT Research Institute has established a European office in Paris for applying computer techniques to numerical control manufacturing. It will provide training and consultation services to European firms interested in the Automatically Programmed Tools system for programming of numerically controlled machine tools and supplies liaison with the APT research staff in Chicago.*

GD President Not Worried

General Dynamics Corp. president Roger Lewis has told a meeting of the New York Society of Security Analysts that, while the percentage of defense spending for hardware may soon begin to decline, he is not pessimistic about the future. He predicted fewer types and numbers of new weapons because of increased effectiveness, which reduces the need for redundancy. Lewis sees increased competition for defense work and predicts more firms will be forced out of the business; however, he said he opposes large-scale conversion from the defense industry to non-defense activities. He pointed out that the defense industry, though privately owned, has a major responsibility for the continued security and defense of the country, and that this responsibility remains despite changes of Administrations and defense philosophies.

contracts

AIR FORCE

$3,420,073—**Hughes Aircraft Co.,** Culver City, Calif., for continued work on a classified project.

$2,230,887—**Continental Aviation & Engineering Corp.,** Detroit, for continued work on a classified project.

$2,000,000—**Bell Aerospace Corp.,** Wheatfield, N.Y., for continued work on vertical takeoff and landing program.

$1,883,373—**Hughes Aircraft Co.,** Culver City, Calif., for repair of fire control systems.

$1,727,357—**Conductron Corp.,** Ann Arbor, Mich., for work on a classified project.

$1,508,848—**Lockheed Aircraft Corp.,** Sunnyvale, Calif., for work on a classified project.

$1,300,000—**General Electric Co.,** Philadelphia, supplemental contract for development and testing of unspecified space vehicles.

$761,606—**The Boeing Co.,** Aero-Space Div., Seattle, for engineering services applicable to the *Minuteman* weapon system.

$738,752—**Panel Corp. of America,** Denver, for tow target, aerial dart, gunnery rocket.

$400,000—**General Dynamics,** Astronautics Div., San Diego, Calif., for services to prepare changes to technical orders of *Atlas E* and *F* series weapons systems.

$249,498—**University of Maryland,** College Park, for a three-year study of the basic structure of metals in an attempt to explain how metals become superconductors at extremely low temperatures.

$150,000—**McDonnell Aircraft Corp.,** St. Louis, Mo., for *Asset* program.

ARMY

$2,750,000—**Sperry Rand Corp.,** Univac Div., Washington, D.C., for the design and installation of a computer-based information system in the Army War Room in the Pentagon.

$2,260,000—**Magnavox Co.,** New York City, for production of radio communications subsystems designated AN/URC-55 auxiliary items.

$450,000—**General Dynamics Corp.,** Pomona, Calif., for FY 1965 *Redeye* R&D programs.

$254,592—**Hesse-Eastern Inc.,** Everett, Mass., for rocket launchers.

$200,000—**General Telephone and Electronics Corp.,** Sylvania Electric Products, Inc., Mountain View, Calif., for a study contract to analyze and evaluate the performance of a variety of missile systems.

$116,300—**Western Electric Co.,** New York City, for *Nike X* DR&TTR receiving components.

$103,570—**Honeywell, Inc.,** West Covina, Calif., for *Redeye* trainer.

$76,359—**Strode Construction,** Cocoa, Fla., for high resolution tracking radar at NASA's MILA.

$54,497—**Planning Research Corp.,** Los Angeles, for extension of contract for engineering services on *Shillelagh* weapon system.

NAVY

$4,843,031—**Western Electric Co.,** New York City, for weapons control equipment for the *Tartar* ship-to-air missile.

$1,315,575—**Radiation, Inc.,** Palm Bay, Fla., to modify communications equipment aboard USNS Kingsport.

$1,300,000—**Baifield Industries, Inc.,** Gardena, Calif., and Carrollton, Tex., three contracts for work on *Talos, Asroc* and *Snake Eye.*

$1,125,000—**Northrop Corp.,** Anaheim, Calif., for engineering work on *Polaris* missile checkout equipment.

$363,777—**Fairbanks, Morse and Co.,** Beloit, Wisc., for test of 10 missile hoisting units (Mk 1 Mod 1), test of nine liner adapters, test of 23 liner lifting attachments and repair of parts.

$131,500—**Atlantic Research Corp.,** Alexandria, Va., to fabricate and deliver *Argas* sounding rocket hardware.

$66,427—**Atlantic Research Corp.,** Alexandria, Va., contract modification to conduct a research program to study the physical properties of solid propellants.

NASA

$17,000,000—**Bendix Field Engineering Corp.,** Owings Mills, Md., a three-year contract to provide launch services for the Kennedy Space Center.

$2,500,000—**Dynamics Corp. of America,** Reeves Instrument Div., Garden City, N.Y., to build three radar tracking antenna systems for the *Apollo* program.

$995,000—**Daniel Construction Co.,** Huntsville, Ala., for expansion and modernization of its high pressure gas systems to support testing of *Saturn V* components.

$822,350—**Ling-Temco-Vought,** Dallas, for standardization of *Scout* program support equipment.

$780,000—**Radio Corp. of America,** Princeton, N.J., for flight model single camera automatic picture transmission subsystem.

$200,000—**North American Aviation, Inc.,** Space and Information Systems Div., Downey, Calif., for a study of ballistic orbital support operations.

$170,700—**North American Aviation, Inc.,** Space and Information Systems Div., Downey, Calif., for a manned Mars and/or Venus flyby vehicle systems study.

$161,616—**Motorola, Inc.,** Military Electronics Div., Scottsdale, Ariz., for command systems test sets.

$146,241—**Giannini Controls,** Duarte, Calif., for study for extending the altitude range of free air density sensing technique.

$142,100—**Lockheed Aircraft Corp.,** Missiles and Space Div., Palo Alto, Calif., for a study of prediction and measurement of the convective heat transfer to a manned spacecraft during re-entry.

INDUSTRY

$3,000,000—**Ampex Corp.,** Redwood City, Calif., from **Radio Corp. of America,** New York City, for magnetic tape handling systems to be used with RCA computers in checkout and launch of *Saturn* boosters.

$1,660,000—**Straza Industries,** El Cajun, Calif., from **Hayes International Corp.,** Birmingham, Ala., for propellant environmental line ducting and assemblies for installation in service arms for *Saturn* launch facilities at Cape Kennedy, Fla.

$500,000—**Royce Instruments, Inc.,** Menlo Park, Calif., from **North American Aviation, Inc.,** for design and manufacture of highly accurate, continuous flow particle monitoring systems for quality control assurance of *Apollo* command module control and guidance systems.

$360,000—**Westinghouse Electric Corp.,** Sunnyvale, Calif., from **United Aircraft Corp.,** United Technology Center, Sunnyvale, Calif., to supply 29 electrical distribution consoles for the *Titan III-C* booster.

$175,000—**Quantic Industries,** Pelmac Div., Inc., San Carlos, Calif., from **Grumman Aircraft Engineering Corp.,** Bethpage, N.Y., for the design and manufacture of explosively operated valves for the Lunar Excursion Module, *Apollo* program.

$70,000—**D.B. Milliken Co.,** Arcadia, Calif., from **North American Aviation Corp.,** Space and Information Systems Div., Downey, Calif., for twelve high-speed data cameras and eleven 1,200-ft. magazines.

$35,000—**Consolidated Systems Corp.,** Pomona, Calif., from **Hughes Aircraft Co.,** Culver City, Calif., for design and manufacture of 16-mm pulse-operated recording cameras for the *Phoenix* air-to-air missile system.

General Telephone and Electronics, Sylvania Electric Products, Inc., New York City, from **General Electric Co.,** New York City, for 12 fuel elements for the University of Missouri, Columbia (amount undisclosed).

United Technology Center, Sunnyvale, Calif., from **General Electric Co.,** New York City, for design and demonstration of a pocket-size "tractor" rocket.

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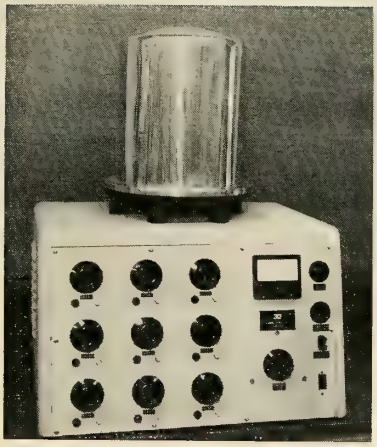
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New Product of the Week: Thermal Conductivity Apparatus

A new instrument designed to provide superior measurements of the rate of heat transmission through a variety of basic materials has been developed by 3M Co.

The device employs a steady state comparative method of measuring this quantity where the thermal conductivity of an unknown material is compared with that of a known material. The apparatus provides an accuracy of ±5% and has the ability to test materials—such as metals, ceramics, plastics, glass and resins—at temperatures from 25° to 1,200°C. Required samples can be as small as one inch in diameter.

In operation, the unknown sample is sandwiched between two identical standards with known thermal conductivities. By adjustment of seven heaters on a guard tube, radial heat flow is eliminated and the same amount of heat flows through known and unknown samples in the axial direction. A thermal balance point is reached when the



temperatures at specific points on the sample column are within 1°C of the respective points on the guard tube.

Circle No. 151 on Subscriber Service Card

Solid-State Programmer

A solid-state programmer that accepts digital information from punched paper tape and generates an analog signal of any arbitrary function is being marketed by CompuDyne Corp.

The Model AFP-810 simulates any arbitrary function or program by a series of straight-line segments. The number of segments required to meet any specific accuracy is inversely proportional to the radius of curvature of the function. Each straight line may be defined by the initial and final amplitude and a slope or rate between these two amplitudes.

Specifications include an amplitude accuracy of ±0.1% and a time accuracy of ± 1%. Repeatability is 0.05% amplitude and 0.5% time. Frequency generation is 16.7 cps maximum for sine wave (5% distortion) and 50 cps maximum for triangular.

Circle No. 152 on Subscriber Service Card

Spectrophotometer

A single-beam ultraviolet spectrophotometer with a wavelength range from 190 to 1,000 mμ has been introduced by Scientific and Process Instruments Div., Beckman Instruments, Inc.

The Model DU-2 features a scale expansion range from 90 to 100% T., and a precision cell compartment which accommodates both microcells and standard cells without requiring auxiliary equipment. The unit is provided with a complement of accessories to measure such phenomena as fluorescence, reflectance, flame emission, reaction rate, enzyme kinetics, microanalysis and column chromotography.

Circle No. 153 on Subscriber Service Card

Sampler-Attenuator

A sampler-attenuator, which precisely levels the output of a sweep oscillator and provides 60-db power control has been announced by Alfred Electronics.

The Model 1150 series has a power variation, with frequency from maximum power down at least 20 db, to ±0.5 db. At minimum power, variation is typically less than 1.5 db. Insertion loss is less than 5 db.

Five models in the series cover the following ranges: 1 to 2, 1.4 to 2.5, 2 to 4, 3.5 to 6.75 and 4 to 8 gc.

Circle No. 154 on Subscriber Service Card

Displacement Transducer

The Decker Corp. is marketing the Model 985-1 non-contact displacement transducer, capable of measuring both dynamic and static motion in the lower micro-inch ranges.

The solid-state device utilizes a change-in-capacitance approach to convert minute displacements to analagous dc and ac voltages. It operates on a 28v dc input and provides a 0 to ±2.5-v dc output. Resolving power is approximately one part in 5,000.

Circle No. 155 on Subscriber Service Card

Precision Clock

Aerospace Research, Inc., is producing the Model PC-111 precision clock. The unit contains a basic oscillator of 1×10^{-8} stability and fail-safe logic producing pulse outputs at periods of 1, 10 and 100 microsecs. and 1 millisec.

A feature of the device is push-button digital stepping of the output pulse position to enable setting the clock to within 10 microsecs. of time reference.

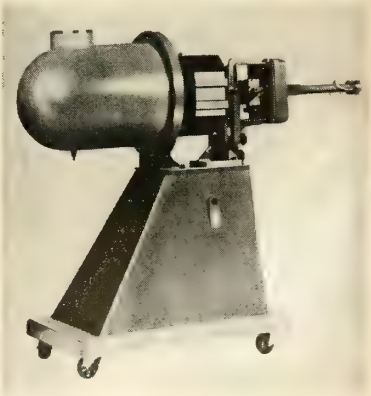
Circle No. 156 on Subscriber Service Card

Neutron Generator

A high yield neutron generator designed for laboratory activation analysis systems has been introduced by Technical Measurement Corp.

The Activatron 111 generator delivers 10^{11} neutrons per second from a high atomic-to-molecular ratio Penning ion source with a 200-liter/second ion pump. Cooling efficiency and operator safety are achieved by immersion of high voltage supply, ion source and accelerator sections in oil baths. Target cooling is accomplished with an integral recirculating water system that increases the half-life of the target. No external water connections are required.

Unit specifications include: neutron flux of 1.9×10^{10} neutrons/cm²/sec.



at target holder back surface; thermal neutron flux of 10^9 neutrons/cm²/sec.; beam current of 1 ma; operating vacuum of 10^{-5} mm Hg range; and power supply variable from 0 to 200 kv dc.

Circle No. 157 on Subscriber Service Card

missiles & rockets

BEYOND APOLLO—THE U.S. SPACE PROGRAM

MISSILES AND ROCKETS will publish its fourth annual NASA issue November 30, 1964. Now accepted as the authoritative publication on the nation's space agency, M/R will examine the National Aeronautics and Space Administration's current and future projects, people and facilities—plus NASA fiscal 1966 budget planning now being considered by the administration.

PUBLICATION DATE
NOVEMBER 30, 1964

ADVERTISING CLOSES
NOVEMBER 16, 1964

With major procurement fo the Apollo manned luna landing program now behin it, NASA is deep in the plan ning of new projects to expan man's knowledge in space Special emphasis is placed i this issue on the U. S. Spac Program—BEYOND APOLL —with detailed description of post-Apollo missions:

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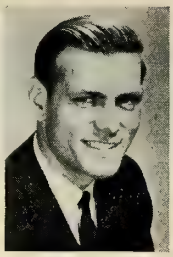
names in the news



HUARISA



GRAHAM



LOYND



GANGNES

John B. Huarisa: Appointed as president and chief executive officer of Standard Kollsman Industries, Inc., Melrose, Park, Ill. He was formerly executive vice president and a founder of Admiral Corp.

Ralph L. McCreary: Named vice president of Watkins-Johnson Co., Palo Alto, Calif. He will be manager of the systems division with responsibility for advanced developments in satellite communications, reconnaissance, electronic countermeasures and surveillance systems.

Varian Associates, Palo Alto, Calif., has elected Dr. Joseph Feinstein as vice president-research and Dr. Robert Jepsen as director, Central Research Laboratories.

Ben H. Ciscel: Appointed executive vice president of International Electronic Research Corp., Burbank, Calif., a subsidiary of Dynamics Corp. of America.

Daniel Willens: Appointed director of the systems design subdivision of Aerospace Corp.'s Applied Mechanics Div., Los Angeles.

John J. Graham: Elected vice president of Curtiss-Wright Corp., Wood-Ridge, N.J. and appointed president and general manager of the Wright Aeronautical Div. **Joseph V. Miccio,** formerly president and general manager of Wright Div., has been promoted to a new position as a senior vice president of the corporation.

Robert W. Stone and William F. Herwig: Joined the Washington staff of Aerojet-General Corp. as rocket and missile engineers.

Sitaram Rao Valluri, Indian Institute of Technology, **James B. Glassco,** Douglas Aircraft Co., Inc., and **George E. Bockrath,** Douglas Aircraft Co., Inc. have been selected to receive the 1964 Society of Automotive Engineers' Wright Brothers Award for their paper on "Further Considerations of a Theory of Crack Propagation in Metal Fatigue."

Gerald A. Rosselot: Appointed vice president of engineering for Bendix Corp., Detroit; and **C. B. Sung** appointed as general manager and director of the research laboratories division.

Bernard P. Miller: Received the 1964 Public Service Award of the National Aeronautics and Space Administration for work on the six-camera television system used on *Ranger VII*. He is *Ranger* Project Manager at Radio Corp. of America, New York City.

Richard B. Loynd: Named president of Builder Products Div., Emerson Electric Co., St. Louis. Also named to new positions were **Phillip D. Pryne,** administrative vice president for Emerson's U.S. electrical motors division; **Robert L. San Soucie,** president of the electronics and space division.; and **Richard P. Lindgren,** vice president-motors for the electrical division.

Thomas Courtney, Jr.: Appointed assistant program manager of program control for the *Saturn* S-II stage program at North American Aviation's Space and Information Systems Div., Downey, Calif.

Col. Harold W. Norton: Joined Atlantic Research Corp., Alexandria, Va., as head of the program management group, engineering division., propulsion and chemical systems.

Paul M. Leland: Joined Viron, a division of Geophysics Corp. of America, Anoka, Minn, as head of the aerospace sciences group.

George P. Baker: Elected to board of directors of Lockheed Aircraft Corp., Burbank, Calif. He is also dean of the Harvard Graduate School of Business Administration.

Alfred V. Gangnes: Elected president of Interstate Electronics Corp., Los Angeles. He has been vice president and general manager since 1961.

John D. Gum: Appointed program manager, systems department at Spectrolab, Textron Electronics, Inc., Sylmar, Calif. He will be responsible for program coordination of the major solar cell assembly and electro-optical instrumentation work.

Newman W. Thibault: Named director of research and development, abrasive division., Norton Co., Worcester, Mass. **Neil N. Ault** was also named director of reseach and development, refractories division.

Julius T. Tou: Joined Battelle Memorial Institute, Columbus, Ohio, as a senior scientist in information and computer sciences research.

—when and where—

OCTOBER

Western States Section/The Combustion Institute Fall Meeting, University of Utah, Salt Lake City, Oct. 26-27.

Joint Meeting of the AIAA and the Canadian Aeronautics and Space Institute, Ottawa, Ontario, Canada, Oct. 26-27.

10th Conference on Welded Electronic Packaging, sponsored by the Society of Automotive Engineers, Belmont Plaza Hotel, New York City, Oct. 27-28.

11th Symposium on Nuclear Science, sponsored by the IEEE and Air Force Office of Scientific Research, Philadelphia, Oct. 27-29.

Fall Meeting of ASTM Committee D-9 on Electrical Insulating Materials, Statler Hotel, Buffalo, N.Y., Oct. 28-30.

Annual Meeting and Exposition of the Society for Experimental Stress Analysis, Hotel Manger, Cleveland, Oct. 28-30.

Electron Devices Meeting, sponsored by the IEEE, Sheraton-Park Hotel, Washington, D.C., Oct. 29-31.

1964 Annual Symposium of the Society of Photographic Scientists and Engineers on Unconventional Photographic Systems, Marriott Twin Bridges Motor Hotel, Washington, D.C., Oct. 29-30.

NOVEMBER

1964 Northeast Electronics Research and Engineering Meeting, Somerset Hotel, Boston, Nov. 4-6.

19th Annual Meeting of the Armed Forces Chemical Association, Mayflower Hotel, Washington, D.C., Nov. 4-6.

Joint Meeting of the U.S. Army Materiel Command and the Institute of Environmental Sciences, Aberdeen Proving Ground, Md., Nov. 5-6.

Modern Theories of Adhesion and Their Applications, sponsored by the American Chemical Society and the University of Southern California, Olin Hall Auditorium, USC, Los Angeles, Nov. 6.

Reinforced Plastics—Principles & Applications, a short course at The University of California at Los Angeles, Nov. 9-20.

Symposium on Optical and Electro-Optical Information Processing Technology, sponsored by ONR, IEEE—Professional Technical Group on Electronic computers, Optical Society of America, and The Greater Boston Chapter of the Association for Computing Machinery, Somerset Hotel, Boston, Nov. 9-10.

Instrumentation in Hazardous Areas, a course sponsored by the Instrument Society of America, du Pont Country Club, Wilmington, Del., Nov. 11-13.

Management Guide to Numerical Control, a seminar sponsored by the Numerical Control Society, The Summit, New York City, Nov. 12-13.

Conference on Ground Testing in Simulated Space Environment, sponsored by the AIAA, Pasadena, Calif., Nov. 16-17.

Third International Symposium on Bioastronautics and the Exploration of Space, sponsored by the Aerospace Medical Div., AF Systems Command, Brooks AFB, Tex., Nov. 16-18.

Tenth Conference on Magnetism and Magnetic Materials, sponsored by the IEEE and the American Institute of Physics, Minneapolis, Nov. 16-19.

Symposium on Microelectronics and Large Systems, sponsored by the Office of Naval Research and the Univac Div. of Sperry Rand Corp., Dept. of Interior Auditorium, Washington, D.C., Nov. 17-18.

Meeting of the Aerospace Research Applications Center, Indiana Memorial Union Building, Indiana University, Bloomington, Nov. 17-18.

Tenth Anniversary Tri-Service Conference on Electromagnetic Compatibility, sponsored by IIT Research Institute, Museum of Science and Industry, Chicago, Nov. 17-19.

Seventh Hypervelocity Impact Symposium, sponsored by the Army, Navy, and Air Force (Secret Clearance and need-to-know certification required for attendance), Tampa, Fla., Nov. 17-19.

Manned Orbital Laboratory Progress Report, sponsored by the American Astronautical Society, Kresge Auditorium, Massachusetts Institute of Technology, Cambridge, Mass., Nov. 18-19.

Northeastern States Navy Research and Development Clinic, sponsored by The Franklin Institute, Philco Corp., Temple University, the University of Pennsylvania, the Office of Naval Material, National Security Industrial Association, and others, Philadelphia, Nov. 18-20.

Sixteenth Annual MAECON Technical Meeting, Continental Hotel, Kansas City, Mo., Nov. 23-24.

Winter Annual Meeting of the American Society of Mechanical Engineers, Statler Hilton Hotel, New York City, Nov. 29-Dec. 4.

7th Annual Army Aviation Contract Services Symposium, sponsored by the National AeroSpace Services Assn., International Inn, Washington, D.C., Nov. 30.

Joint Meeting of the American Nuclear Society and Atom Fair, Hilton and St. Francis Hotels, San Francisco, Nov. 30-Dec. 3.

DECEMBER

57th Annual Meeting, American Institute of Chemical Engineers, Statler Hilton Hotel, Boston, Dec. 6-10.

131st Annual Meeting, American Association for the Advancement of Science, Boston, Dec. 26-31.

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The History Lesson

THE MEMO was on the desk of Donald Douglas. It read:

"We are all very much concerned over the drastic contracts that the government insists should be executed to do this work. They are not going to allow us to make any money; at the same time, the government will take no risk whatever, demanding that the manufacturers take their own hazards and risk big losses, but with no opportunity to make profits."

We are moved to print that bit of correspondence in the wake of the Navy's senseless decision to begin taking developed weapons systems out of the hands of firms which participated in their research and development to put them up for open bid in the profitable production stage.

Timely as that memo might seem, the date on it was September 5, 1917. It was signed by Glenn L. Martin and is recorded in Henry Still's excellent biography of Martin.

If the aviation pioneer still were alive, he might today be writing another such memo to Donald Douglas, for the Martin Company was one of the first affected by the new Bureau of Naval Weapons policy.

The Martin Co. lost the *Bullpup* air-to-surface missile production contract to Maxson Electronics Corp. Maxson also was a successful bidder on the production contract for Beech Aircraft's *AQM-37A* missile target drone. Maxson is among 17 firms asked to bid on the major guidance and control production contract for the *Sidewinder 1C* air-to-air missile, a system developed primarily by Philco. The *Astor* ASW missile is the next to be subjected to this inane policy.

The very able president of Maxson is frank to admit that one reason for the firm's success is that it is not burdened with the heavy research and development overhead of larger aerospace companies.

We can understand the Maxson enthusiasm for the Navy policy. But we most certainly cannot understand the Navy decision to follow a route which threatens not only the basic stability of industry research and development but also the very effectiveness of the future weapons upon which the Navy itself will depend. It is made plain, however, that the functioning of the industry is no better understood by government now than at the time Mr. Martin penned his note to Mr. Douglas 47 years ago.

Since the Navy was a considerable benefactor of early Martin research and development, it might be educational to the defense executives responsible for the new BuWeps policy if we review some of the history in Mr. Still's book.

It is notable that Glenn L. Martin's anger was due in part to the government's disastrous decision to turn over World War I aircraft production to the automobile manufacturers—an interesting coincidence since a former automotive executive holds the responsibility for the Navy's present policy. In World War I, you will recall, not one American-built plane reached the front by Armistice Day.

The Glenn L. Martin Co. was destined to become one of the fountainheads of the aerospace industry, since working for Martin at that time, in addition to Douglas, were such other industry pioneers as Lawrence Bell and J. H. (Dutch) Kindelberger. These all were men who were willing, both then and later, to invest their own time and money in projects which they believed were worthy of government production contracts. One of the first was the MB-1 bomber, which Martin urged upon the government and which proved one of the most durable aircraft of the U.S. Air Service in the post-war period.

The MB-2, ready for delivery in 1920, could carry a 3,400-lb. bombload to 30,000 ft. It was the outstanding U.S. heavy bomber for a full ten years. Where would the MB-2 improvements have come from had the MB-1 production contract been taken away from Martin and given to a Maxson?

In the thirties, Martin designed and built the twin-engine B-10 bomber at company expense to enter a U.S. Air Corps competition, which it lost to the Boeing B-9. Further company funds were poured into improving the B-10, until its performance assured it a role as the fastest and most powerful bomber in the world. The Army ordered 117 of them. As Mr. Still notes, it set the pace for all bomber design in that decade and its development was honored by the award of the Collier Trophy.

Certainly, it is fair to raise the question of where the money came from that the company put into development of the B-10. It came from profits made on the MB-1 and MB-2 and on such Navy aircraft as the BM-2 and the PM flying boats, profits that might not have existed had those production contracts gone elsewhere.

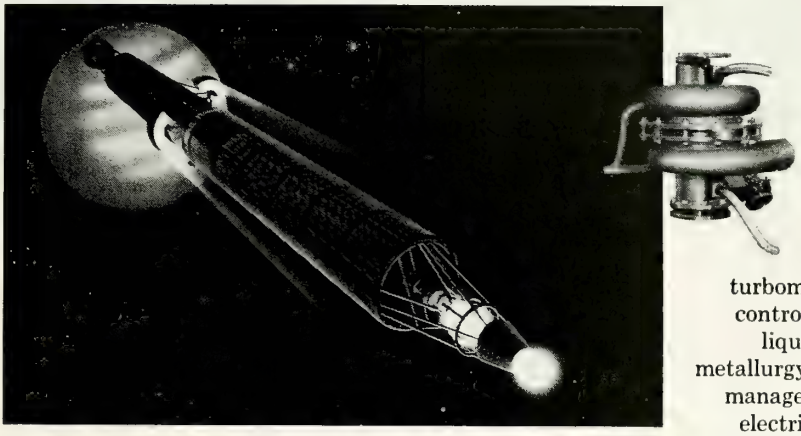
NOR IS IT NECESSARY to remain with aviation history to find examples of company foresight and funding in research which have been of major benefit to the government. One of the first to come to mind in the missile field is Convair's decision to carry on development of a long-range ballistic missile when the government economy axe fell on Project MX-774. Pressed by Charlie Bossart's conviction that there was an ICBM in the company future, Convair put its own funds into ICBM research throughout 1949 and 1950. When government interest was renewed in 1951, Bossart and his team were ready with some important improvements, including the stage-and-a-half design and the addition of verniers for directional control.

We could cite many such examples. It probably is safe to say that no major weapon system has been developed which did not see substantial financial participation by the manufacturer in the research stage. It is hardly remarkable, therefore, that the major aerospace firms are deeply concerned by the new Navy open door policy on production contracts, a policy which can make it unattractive to risk company funds on promising research and development.

Any apparent cost reduction achieved by this policy is a temporary and fallacious one. Its eventual cost to the Navy and to the nation can be disastrous. We recommend the Navy be ordered to cease and desist at once.

William J. Coughlin

It's possible that some people have never heard of a project called SNAP-50/SPUR. But they will.



Chances are this nation has never had a more challenging space project than this attempt to supply man-in-space with electrical power.

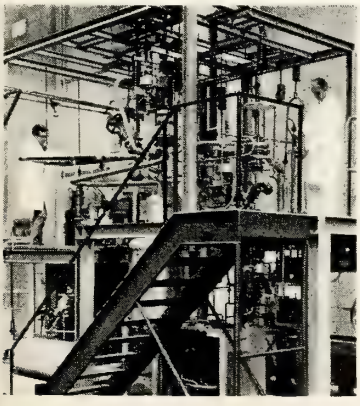
And that means enough electricity to provide a mission with *all* the power needed for space communications, propulsion, research, weapons and life support.

This is SNAP-50/SPUR.

It is a brilliant answer to some demanding questions:

How do you build a power station that must be a giant in output, but small in size and weight?

How do you invent a space power station that furnishes reliable, continuous power for more than a year?



The solution staggers the imagination.

Yet, such a system, designated SNAP-50/SPUR, is now being developed under the sponsorship of the Atomic Energy Commission and United States Air Force.

SNAP-50/SPUR will employ a nuclear reactor as a heat source to operate turbines that will drive electrical generators. Heat rejection and cooling is accomplished by a cylindrical radiator.

Working temperatures in the system are near that of molten iron. Here, conversion and rejection of heat demands the most advanced technologies.

Closed loop power conversion systems necessary for this kind of power production are being designed and tested by Garrett-AiResearch.

Garrett-AiResearch, with 25 years of experience in research and production of heat transfer, turbomachinery, control systems, liquid metals, metallurgy, thermal management and electrical power management has already developed much of the technology to be used in SNAP-50/SPUR power conversion equipment.

Today, in Garrett labs, turbines and heat exchangers are being operated with alkali metals at high temperatures.

Major components will be tested this year in Garrett's Phoenix facilities. Turbodynamic bearing tests (picture at left) are already in operation.

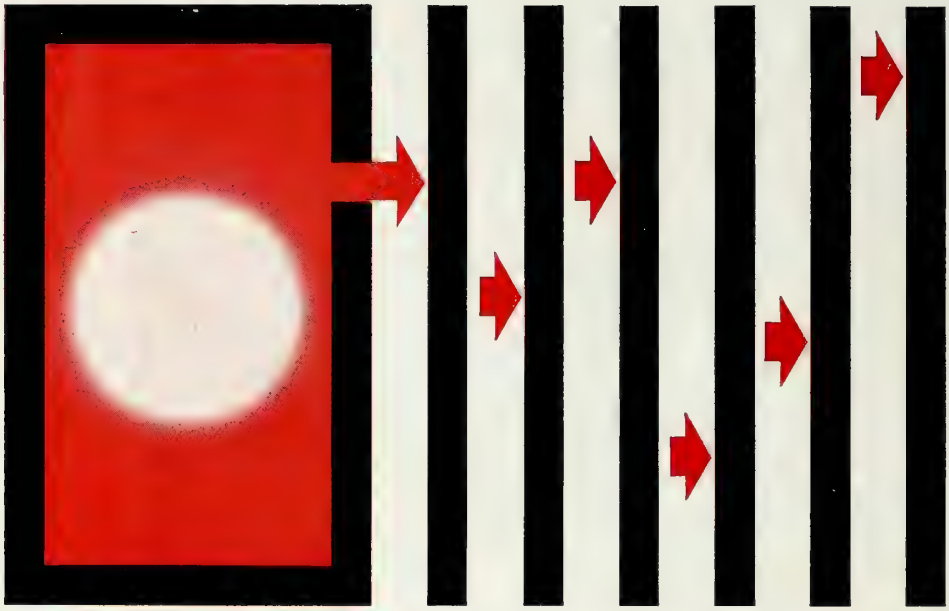
SNAP-50/SPUR is a rewarding assignment – actually the forerunner of future space power plants. Certainly, it demands unique capabilities. That's why Garrett is playing such an important role. Because . . .

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missiles and rockets

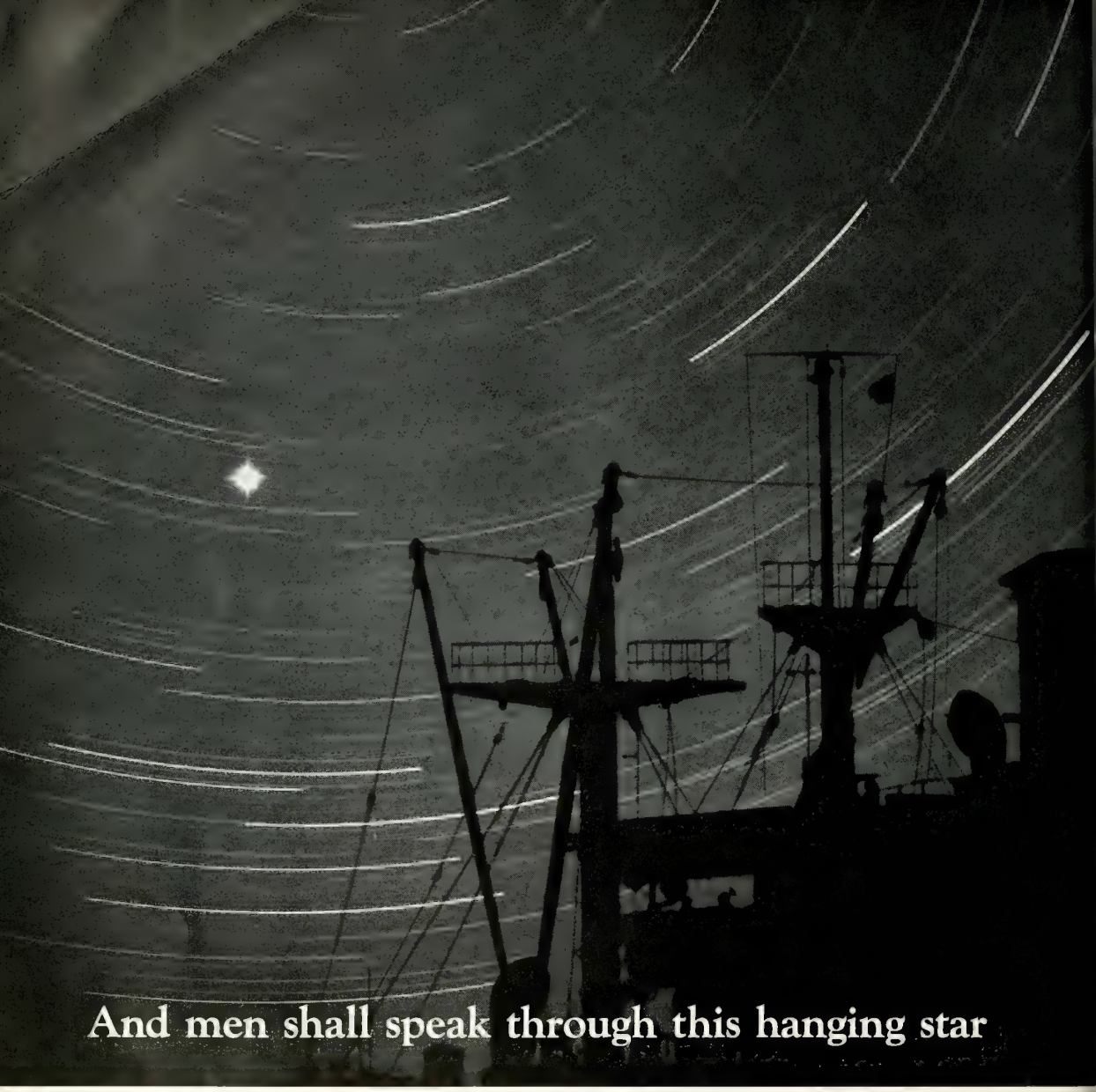
THE WEEKLY OF SPACE SYSTEMS ENGINEERING

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Radar Antenna Radome Inspected at Goodyear

Navy Outlines Plans for ASMS System . . .
Arma Div. Nears Fateful Decision . . . . . .
Weber's Gemini Pilot Ejection System . . . . . .



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missiles and rockets

THE WEEKLY OF SPACE SYSTEMS ENGINEERING

Volume 15, Number 18 November 2, 1964

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Published each Monday with the exception of the last Monday in December by American Aviation Publications, Inc., 1001 Vermont Ave., N.W., Washington, D.C. 20005. Cable Address: AMERAV.

Printed at Judd & Detweiler, Inc., Washington, D.C. Second class postage paid at Washington, D.C.

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Subscription rates: U.S. and Possessions, Canada, and Pan American Postal Union Nations: 1 year, $5.00, 2 years $8.00, 3 years $10.00. All other foreign: 1 year $15.00, 2 years $25.00, 3 years $35.00. Air freight to Europe: 1 year $20.00, 2 years $30.00, 3 years $40.00. Single copy prices: regular issues 50 cents each; special issues $1.00 each. Subscriptions are solicited only from persons with identifiable commercial or professional interests in the missile/space industry. Subscription orders and changes of address should be referred to Circulation Fulfillment Mgr., Missiles and Rockets, 1001 Vermont Ave., N.W., Washington, D.C. 20005. Allow 4 weeks for change to become effective and enclose recent address label if possible.

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THE COVER



Dome designed to protect a radar antenna undergoes inspection at Goodyear Aerospace Corp., Akron, Ohio. Test model was built under contract to Bell Telephone Labs, and gets its strength from its shape, which transfers stresses to base. Gaps in glass fiber skin will be closed.

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48,125 copies this issue

letters

Space Age Lethargy

To the Editor:

I read with interest and appreciation you Oct. 19 editorial ("The Gauntlet"). There is little doubt in my mind that a large part of man's future will be concerned with space exploration. In this regard, I have been extremely disappointed at the efforts of the United States.

A significant sidelight on this situation is that we have probably the most extensive publishing program of space science books in this country. However, the response to this program has been most disappointing and has necessitated a severe re-evaluation of our future publishing in this field. As an example, your article quotes Kenneth Gatland, of the British Inter-Planetary Society, indicating that *Voskhod* is the complete answer to those who have been saying the Russians had lost interest in sending men to the Moon. In 1964 we published Mr. Gatland's book on Telecommunication Satellites, for North American distribution. This text was originally published by ILIFFE Books Ltd. in England. Much valuable information on Telecommunication Satellites is contained in this volume and it was prepared with the cooperation of a large number of companies and agencies, including NASA. Although we promoted this book extensively (as well as other texts in our Space Technology Series), we distributed less than 500 copies.

It was an interesting coincidence to find in the same issue of M/R Mrs. William Fleming's letter to the editor regarding the lack of available material in the space field. Mrs. Fleming indicated that her 15-year-old son has an insatiable yearning to learn more about space, but most schools don't offer any such material in their course of study. Mrs. Fleming is quite right!

Our experience shows a lack of continuing education among our professional people (regardless of the reasons involved). If, as we find it to be, there is little motivation or availability for high school or college students to learn more about the space science and technology field, I cannot help but shudder when contemplating America's future in this most important area.

Walter R. Welch
Engineering Editor
Prentice-Hall, Inc.
Englewood Cliffs, N.J.

Squashy Subject

To the Editor:

Your Oct. 12 editorial ("A Bit of a Squashy Subject") struck a particularly responsive chord with me. Mr. McNamara has apparently forgotten the lesson taught by Prohibition.

The problem of govenment *and industry* attempting to provide comprehensive and all-embracing instructions and standards is one of serious proportions in many other areas as well. The objective seems to be the elimination of judgment factors from all fields of endeavor, no matter how simple or complex. Presumably we will ultimately be able to expect any inexperienced layman who is a proficient reader (a fairly exacting qualification) to satisfactorily perform any task and be possessed of faultless morals after having merely read the appropriate manuals.

R. L. Gifford
Jackass Flats, Nev.

Pound-Foolish?

To the Editor:

It is incredible to me that, as reported in M/R, Oct. 19, NASA apparently won't make any attempt to significantly increase its FY 1966 budget request because a "crash program" would cost several hundreds of millions of dollars and would gain at best only 6-12 months in the present U.S. lunar landing schedule.

Six to 12 months is easily worth several hundreds of millions of dollars if it could decide the Moon race.

Les Garrault
Chicago

ESRO Launches

To the Editor:

In your article "ESRO Facility To Buy U.S. Equipment" (M/R, Oct. 19, p. 24) you state that "the organization will have to pay for *Scout* launches of the relatively small *ESRO I* and *ESRO II* satellites . . ."

This is quite wrong. The Memorandum of Understanding signed by ESRO and NASA includes both of these satellites in the framework of NASA's international programs, and the launching (including provision of the launch vehicle) will be NASA's contribution to this cooperation.

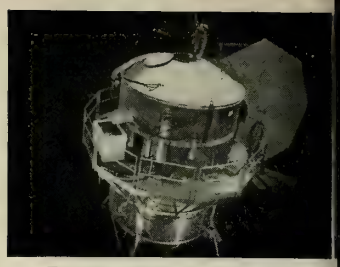
A. Dattner
European Space Research Organization
Paris

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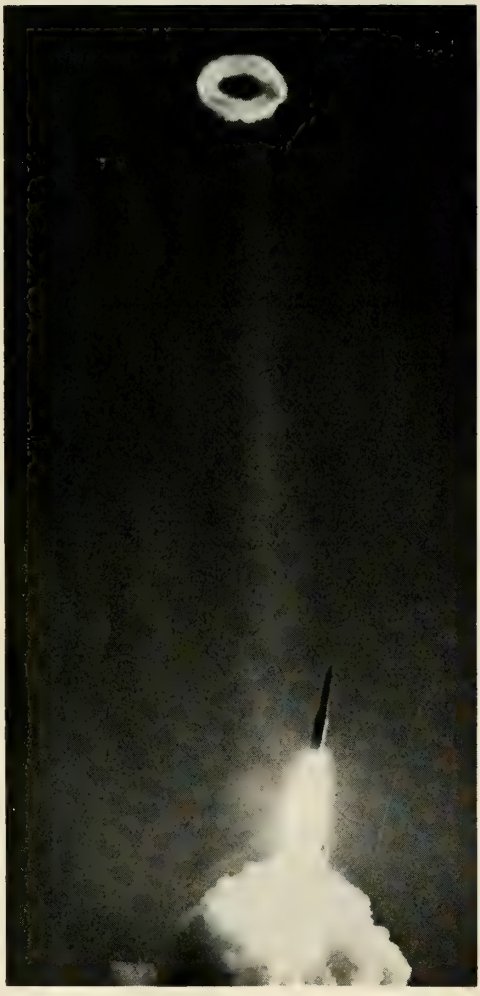
GENERAL ELECTRIC

Space payload to space pilot
G-E MOL study advances man's evolving space role

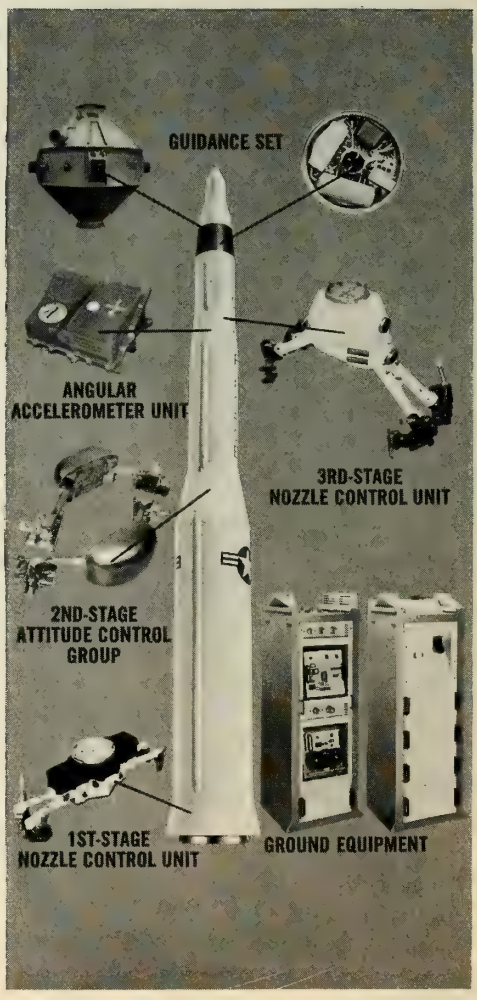
MISSILE AND SPACE DIVISION GENERAL ELECTRIC

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MINUTEMAN II SCORES COMPLETE SUCCESS ON 5000-MILE MAIDEN TEST FLIGHT



IT WAS THE FIRST MISSILE FLIGHT WITH FULLY-INTEGRATED MICROELECTRONICS SYSTEMS



The first flight of the Minuteman II represents a breakthrough in the application of microelectronics to military and space systems. The guidance, control, and checkout systems for the Minuteman II were designed, developed, and produced for the U. S. Air Force by NAA/Autonetics and its nationwide team of suppliers.

North American Aviation **Autonetics Division**

The Countdown

WASHINGTON

NASA Considers LEM Radar Backup

NASA is studying the possibility of a back-up development for the RCA rendezvous radar system for the Lunar Excursion Module. This move would be preceded by a study contract from Manned Spacecraft Center. NASA is not dissatisfied with RCA but regards the radar area as one of high risk.

MOL Bids To Be Asked Soon

Air Force's *Manned Orbiting Laboratory* is far from dead —despite a report in a weekly aviation magazine. Top government officials say the requests for proposals will go out early this month. The account of the program's demise is described as "completely wrong."

Sullivan Takes Over at OART Division

Frank Sullivan was selected as acting director of the Electronics and Control Division of NASA's Office of Advanced Research and Technology, effective Nov. 1. He was deputy director to Dr. Albert J. Kelley, now deputy director of the Electronics Research Center.

Technical Solutions Needed for Voyager

The *Voyager* spacecraft program is said to require development of an isotope power supply capable of generating about 300 watts. Another major technical hurdle is the need for significant improvement in stability of radio frequencies required to track the spacecraft accurately.

Centaur Launch To Carry Dummy Surveyor

Centaur 4 launch—still scheduled for Cape Kennedy about Nov. 17—will carry aloft an object simulating the *Surveyor* spacecraft. NASA hopes to get a complete burn of the *Centaur* stage engines that will propel the spacecraft simulator and the stage into elliptical orbit. This also will permit a test of the hydraulic pump which marred the *Centaur 3* flight last summer.

Agena To Use Nitrogen Tetroxide

One of the basic assumptions of the *Titan III-X* program is that the *Agena* upper stage would use nitrogen tetroxide (N_2O_4) as an oxidizer rather than red fuming nitric acid. This would boost specific impulse of the *Agena* by better than 25 seconds and enable the vehicle to put a heavier payload into orbit.

INDUSTRY

Look Out, Here He Comes Again

Maxson Electronics Corp., which in the period of a few weeks earlier this year won sole-source production contracts on the Martin *Bullpup* air-to-surface missile and the Beech *AQM-37A* missile target drone, now is rumored to be at or near the top of future production source selection lists for the *Walleye* air-to-surface glide bomb and the *Shrike* air-to-surface anti-radiation missile. These all are Navy programs contracted for by the Bureau of Naval Weapons.

GD/A Studies Rotational Environment

An experiment to study man's adaptability to a rotational environment on long space missions is being conducted by General Dynamics/Astronautics life sciences division in San Diego. Four research engineers will enter a whirling chamber for eight days to carry out spin tests and psychological and physiological experiments. The box-like chamber is mounted on the arm of a centrifuge.

Hughes Scientists Miffed at Syncom Use

A number of Hughes scientists and engineers who worked on the *Syncom III* communications satellite are irked at the failure of NBC to make better use of it during the Olympic games in Tokyo. The network locked up *Syncom's* time during the Olympics but used it live only for the opening ceremonies. Even those were carried on tape for the West Coast.

INTERNATIONAL

French Hush Electronic Development

Sources close to the French IRBM program say a remarkable amount of highly sophisticated electronic hardware has been developed and is in production for the program and its accessory fields. Little information is being released on these developments, however, due to the desire of the French government to break the news at the 1965 Paris Air Show.

British Buy May Boost Sparrow Market

Substantial agreement was reached last week between the U.S. and Britain on development of two prototype McDonnell F-4 fighters for the Royal Navy. The program could result in significant new business for Raytheon, which manufactures the *Sparrow III* air-to-air missile, primary armament for the fighter. The F4-C houses four *Sparrow III's* semi-submerged in the fuselage, with a similar arrangement expected in the British version. Production buy under consideration is a large one.

Sweden Okays Saab 305 Missile Program

The Swedish Air Force has been authorized $3.3 million for continued development of the Saab *305* air-to-surface radio-guided missile. An additional $1 million has been provided for general missile research.

Chinese Missile Threat Seen Distant

Pentagon insiders believe a delivery system for the new Chinese Communist A-bomb is a long way in the future. They say Chinese efforts at missile research and development have not been very successful. Secretary McNamara predicts it will be years before the Chinese complete development of even short-range missiles.

Work Starts on First ESTRACK Station

Ground has been broken in Belgium for the first ESTRACK (European Space Tracking) station in the ESRO system. This will be the main unit of the system.

The Missile/Space Week

NERVA System Test Jumps Year

The first system configuration test of the *NERVA* nuclear rocket engine complete with reactor is now scheduled for fall, 1965, more than 12 months earlier than originally planned.

The decision by the joint NASA-AEC Space Nuclear Propulsion Office to update the test stemmed from the recent highly successful Kiwi-B-4E (Los Alamos Scientific Lab) and the NRX-A2 (Aerojet-General, Westinghouse Electric) full-power and restart reactor tests.

The test date acceleration will probably mean an expanded effort at Aerojet in component and subsystem development and testing.

RFP's Issued for Space Engine

Marshall Space Flight Center has requested proposals by Nov. 30 for the development of a 100-lb.-thrust rocket engine for manned space flight systems.

The multi-purpose engine—to be called the C-1—could be employed for spacecraft attitude control and maneuvering systems and launch vehicle ullage and attitude control systems.

The engine will be powered by monomethylhydrazine (MMH) and nitrogen tetroxide. Eight nozzle configurations will be needed for use in its various possible applications.

Interested firms must submit technical proposals by Nov. 30 and cost proposals must be submitted one week later.

Two firms will be selected to do parallel work during the six-month definition phase of the program. Phase I will be done under a fixed-price contract.

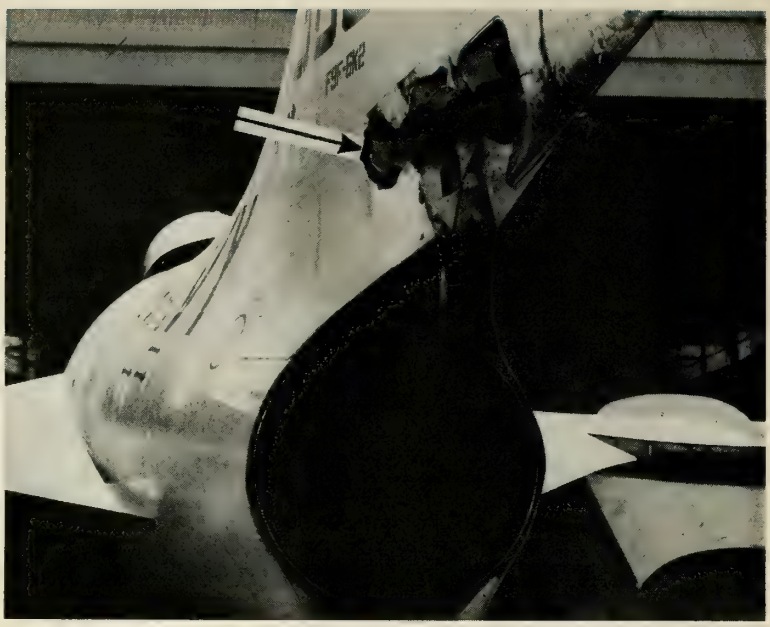
If the program is continued past the first phase, the development phase is expected to be with one of the original contractors under an incentive-type contract.

Detection Satellite Launch Set

NASA has scheduled a launch of its *S-55C* meteoroid detection satellite for no earlier than Nov. 5 from Wallops Station, Va.

If successful, it will be designated *Explorer 23*. Its planned orbit is 637 mi. high and 205 mi. at its closest point to Earth. Its orbital period is expected to be 99.6 minutes.

An earlier version of the satellite, *S-55B*, circled the Earth for seven months after its launch on Dec. 16, 1962, and provided the first sampling of meteoroids in near space.



Positive Proof of Redeye Effectiveness

ARMY'S REDEYE air-defense missile successfully intercepted this Grumman F-9F jet target drone recently during a development test-firing at China Lake, Calif. (M/R, Oct. 26, p. 10). The shoulder-fired missile was not carrying a warhead. Part of the missile can be seen imbedded in the tail section (arrow) of the plane, which was travelling at more than 420 knots. General Dynamics/Pomona is Redeye prime contractor.

Shots of the Week

The Air Force on Oct. 28 successfully launched the fourth in its series of *ASSET* lifting body experiments. The vehicle impacted some 900 miles from Cape Kennedy near Grand Turk Island after achieving a maximum altitude of more than 30 miles. The shot was termed "very successful" and data flow over the two VHF channels was said to have been good. No recovery of the craft was attempted. Two shots of *ASSET* remain in the series.

- The American Science & Engineering Corp. launched the 500th *Aerobee* sounding rocket on Oct. 26 from White Sands Missile Range, N.M.
- The Soviet Union last week launched two more satellites in the *Cosmos* series. *Cosmos 49* and *50* scientific satellites were sent into orbit on Oct. 24 and 27 respectively.

Phillips New Lunar Official

The space agency has named Maj. Gen. Samuel C. Phillips director of the *Apollo* lunar program.

Since Jan. 15 he has served as deputy director under Dr. George E. Mueller, associate administrator for manned space flight and acting *Apollo* director.

Before assignment to NASA, Phillips was Vice Commander of the Air Force Ballistic Systems Div.

ComSat Hopeful of FCC Ruling

The Communications Satellite Corp. is hoping for a quick and favorable ruling from the Federal Communications Commission on control of the U.S. ground stations for the international satellite communications system.

ComSat filed its second statement with the FCC last week in answer to several requests that the corporation be denied ownership and operation of the initial stations.

Arguments for ComSat control included the fact that the corporation

would have no conflicting interest in the form of competing international communications systems, as might communications common carriers opposing the request.

Corporation officials told MISSILES AND ROCKETS that development of the stations must begin soon in order to be ready when the first satellites are launched in 1966. Lead time for ground station development is approximately 18 months.

ARPA Building Seismic Array

A major new seismic array will be built by the Advanced Research Projects Agency in the Miles City-Glendive area of Montana as part of its activities in the detection of underground nuclear tests. Work is scheduled to start in the near future, with equipment installation to be completed by next summer.

Compared with five arrays ARPA has built and is now operating in Oregon, Utah, Tennessee, Arizona and Oklahoma, this unit will be large-sized. Operational arrays are on the order of 12 km. while the new array will be on the order of 200-500 km. Located in the U.S. for convenience, the new seismic installation will investigate design problems of a large array. Initially, the seismometers will be located either on the surface of the Earth or perhaps 100 ft. below. Eventually, ARPA may build a deep-hole array, but this is comparatively expensive.

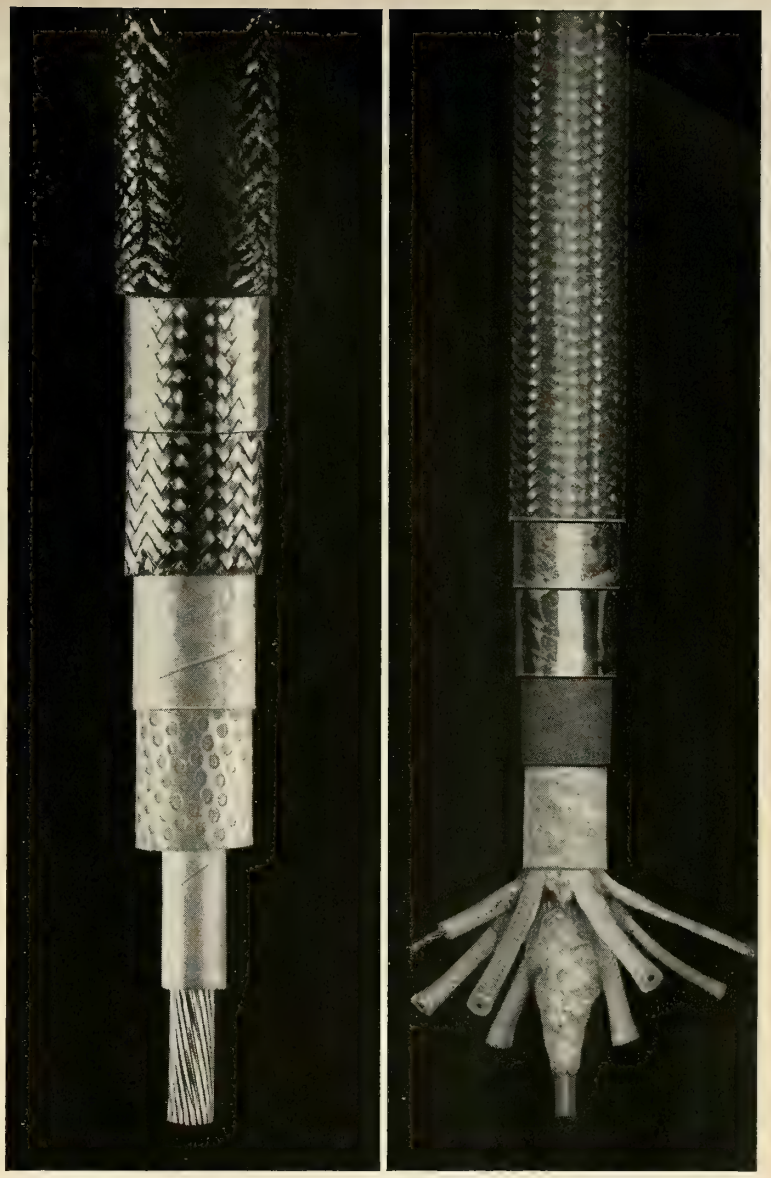
GT-3 Vehicle Goes to AF

The Air Force has taken delivery of the first manned *Gemini (GT-3)* launch vehicle from the Martin Co. Turnover of the vehicle from the Air Force to NASA is to occur later this year at Cape Kennedy.

The vehicle *(GLV-3)* is the third of the 15 *Titan II* launch vehicles to be built by Martin. The present schedule calls for *GLV's* to be turned out at a rate of one every quarter.

Correction

AN ITEM in M/R, Oct. 26 (p. 10) reported that International Telephone and Telegraph Corp.'s Intelcom subsidiary had told the FCC it opposed giving ComSat Corp. exclusive rights to build and operate ground stations. The statement actually was made by ITT itself; Intelcom has no business relationship with either ComSat or commercial aspects of ITT.



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3-T Successor Develops Slowly

by James Trainor

A CONTRACT for full-scale development of an *Advanced Surface Missile System* (*ASMS*) for fleet air-defense in the 1970's "could not be executed" prior to calendar year 1966, a Navy official has told MISSILES AND ROCKETS. Program definition of the system is expected in the second half of 1965, however, after selection of Program Definition Phase (PDP) contractors by the middle of the year.

One of the prime reasons for the Navy's slowness on the *ASMS* program is its desire to have available the test results from critical components of the *Typhon* system. These systems have been installed aboard the USS Norton Sound and are scheduled to undergo a one-year test.

Meanwhile, the Navy is continuing its "get-well" program on the *Tartar, Terrier* and *Talos* surface-to-air missiles now deployed in the fleet and is working on a standardized missile to replace the *Tartar* and *Terrier*. Both of these programs are moving along well, Navy officials say.

● **ASMS plans**—In August of this year, the Navy awarded pre-program definition contracts to seven industry teams to study the *Advanced Surface Missile System*. These contracts are to run for five months, with initial funding of approximately $500,000. The companies involved include Raytheon, Boeing, Sperry Rand, General Electric, Westinghouse, Radio Corporation of America and Hughes Aircraft.

The advanced missile system, like its predecessor, the now-cancelled *Typhon*, is to provide fleet air-defense against the targets anticipated in the 1970 time period—including high-performance aircraft and air-to-surface missiles. Beyond *Typhon*, however, the Navy is looking for a smaller, more compact system which could be employed by destroyers as well as larger ships. *Typhon* had grown so much by the time of its cancellation that it could be deployed only on a relatively small number of the Navy's larger ships.

Reliability is another requirement the Navy is imposing. *Typhon*, Navy officials say, "had so many travelling wave tubes" that it promised to be a very unreliable system. Finally, advances in technology over the *Typhon* are expected to reduce the power requirements of the missile launch and fire-control system. These were prohibitive in the *Typhon* system, officials say.

Typhon technology is not being discarded, however; in fact, it will form the basis for several major systems in the *ASMS*. Specifically, the *Typhon* equipment installed on the Norton Sound will be used to test a new, "highly effective" Ludenberg Lens radar and a computer control system for the radar. An "all-up" systems test, scheduled for next spring, is expected to answer effectiveness questions for the Navy before the systems are put into the *ASMS* concept.

By the time program definition begins next summer, the Navy expects to have the technology and component development well enough in hand to convince the Dept. of Defense to authorize PDP. Although a previous announcement in August estimated that only four contractors would be carried forward into program definition, Navy officials now say that they cannot estimate how many of the seven will be carried forward—and they do not want to "prejudge" the pre-PDP competition.

● **Standardized missile**—In order to ease the logistical support required for three fleet air-defense weapons and to increase the reliability and effectiveness of shipboard missiles, the Navy is developing a missile to replace *Tartar* and *Terrier*. This will not be a new system. Rather, it will use existing launchers (with minimum adaption) and fire-control system—merely adding a booster to achieve greater range.

The standardized missile will be based on the *Terrier* homing missile now being procured. Procurement of the new system is expected to begin in Fiscal Year 1967 or '68.

● **3-T program**—One of the most controversial subjects in Congress is the status of the *Tartar, Talos* and *Terrier* missile programs. All four committees of the Congress which deal with military affairs have criticized the low kill probabilities and high level of down-time associated with these three weapons.

However, since 1962, the Navy has established a special, high-priority program under the management of Adm. Eli T. Reich to correct these deficiencies. Some $275 million will be spent on what has come to be known as the "3-T get-well program." Encouraging results have been obtained, Navy officials report. They single out the operational readiness of *Tartar* as a dramatic improvement.

Reich bristles at the criticism aimed at the $1.3-billion 3-T program. He notes that naval guns were perfected over the course of 100 years while fleet air-defense missiles have been with the Navy for only about 10 years. Also, he feels, some hard and courageous decisions were made in the 1950's, when it was decided to replace guns with missiles.

The lead time for ships, he points out, is 3½-4 years. Hence to have a missile capability in the 1960's, the decision to outfit the ships had to be made while there were relatively few missile ships—and even those were still in development.

"The point before the house," he says, "is that we're on the upgrade in terms of effectiveness and what pays off is having something operational." Also Reich claims, the real test is "what system are other navies buying?" He answers his question by citing interest in the 3-T's in Italy, France, West Germany, Australia and Japan.

Finally, one of the major problems has been the geometric growth in the number of missile ships—from one in 1955 to 74 in 1966. This has caused a host of problems across the board—from logistics, personnel and training to availability, readiness assessment and performance. By 1966, however, when the "get-well" program is expected to end, the fleet air-defense missile problem should be well resolved. ■

Newell discloses . . .

Science Academy Wants Post-Apollo Priority for Unmanned Planetary Shots

by Hal Taylor

THE NATIONAL Academy of Sciences disagrees with NASA's top management on how the agency should plan its post-*Apollo* space programs.

The Academy's Space Sciences Board has informed NASA Administrator James E. Webb that it strongly favors a vigorous, imaginative program of exploration of the solar system.

As part of the program, the Board said, it wants NASA to give a higher priority to unmanned planetary effort (including exobiology) than to a large-scale follow-on of the current manned lunar-landing program or to manned Earth-orbital missions.

The Academy position was revealed by Homer E. Newell, Deputy Associate Administrator for Space Sciences and Applications, in a speech before a meeting of the Institute of Electrical and Electronics Engineers—Professional Technical Group on Nuclear Science in Philadelphia Oct. 28.

Newell, who heads NASA unmanned programs, also indicated that he endorses the Academy's position. He told the group that "this, I believe, reflects the general opinion of the scientific community and is an important factor to weigh with all the other factors that must be considered in deciding on what next (post-*Apollo*)."

● **Front-office view**—Top NASA management apparently does not agree. Dr. Robert C. Seamans, Jr., associate administrator and general manager of the space agency, recently told MISSILES AND ROCKETS the agency's immediate post-*Apollo* program will include manned orbital flights of one to two months, manned polar- and synchronous-orbit flights, extended exploration of the Moon with the Lunar Excursion Module truck spacecraft, and unmanned exploration of Mars with the *Mariner* spacecraft in 1969 and with the *Voyager* spacecraft in 1971 (M/R, Oct. 26, 1964, p. 14).

He indicated no higher priority for the latter two projects. In fact, he said that in the 1970's the agency probably would move to manned Earth-orbital operations of six months to one year. Plans are for a mobile laboratory for extended lunar exploration, post-*Saturn V* launch vehicles, and other projects such as recoverable boosters.

Evaluated simply on the basis of cost, the manned projects would cost billions of dollars more than the estimated $2-to-3-billion pricetag for unmanned exploration of Mars.

Other space agency officials refused to comment on the Academy position. They said NASA had requested the Academy's comments to aid its decision-making process. As such, they said, "it is an internal working document and will not be publicly released."

The decision to which they refer will be made in connection with the Fiscal Year 1966 budget, which goes to Congress next January.

● **Voyager prerequisites**—Newell, in discussing unmanned exploration of Mars, also revealed some of the technical problems that will have to be solved before *Voyager* flights can be accomplished.

"The present nominal life of spacecraft, components and experiments is from six months to a year. In a Mars mission the spacecraft and the experiments must last that long even before the useful part of their life begins.

"In addition, in order to avoid contaminating the atmosphere and surface of Mars with living organisms from Earth, we must take stringent steps to kill such organisms prior to launch. So far the most reasonable method for sterilization involves heat-soak at 135° F for about 24 hours. Thus, we need instruments which can survive this and live for the 180-day flight to Mars and then perform their job for an additional one to six months," Newell declared. ■

NASA Not Planning to Close Marshall

A NASA SPOKESMAN reports that some high-level management personnel close to the Marshall Flight Center's manufacturing activities will be transferred to the Michoud, La., plant.

The agency, however, has no plans to close down the Marshall center or move it *en masse*.

This was the reaction last week to charges that Administrator James E. Webb was injecting politics into the space program when he allegedly told Rep. Hale Boggs (D-La.) that NASA would analyze the Congressman's proposal to move the Wernher von Braun rocket team from Huntsville, Ala., to Michoud.

President Johnson is not on the ballot in Alabama. Although reportedly running behind in Louisiana, he is still accorded some chance of capturing the state by some political observers. Various publications charged that the hint that Marshall might be moved would help the President in Louisiana and aid in the re-election of Boggs, the House Democratic whip.

A NASA spokesman took sharp exception to that view. He declared that Webb had been invited to speak in Alabama by the State Chamber of Commerce and made four appearances before chamber groups. During a question-and-answer period, the informant said, Webb commented that the space agency was having trouble recruiting high-level management personnel for the Huntsville center because of "Alabama's poor reputation."

There are reports that one of the center's top officials is leaving after only one year because his family does not want to live in Alabama.

Webb says he has interviewed 30 applicants for the job and all have refused.

While denying that the Marshall center would be moved, the spokesman said that if the recruiting situation does not improve, "we will have to face up to the problem."

Webb reportedly told a reporter in Huntsville that the "shape-up" period was "several years."

The move of the manufacturing personnel is logical because most of this activity will move to Michoud as the *Saturn I* development at Marshall ends.

Army Considering Expansion Of SECOR Satellite Mapping Program

AN EXPANDED *SECOR* program is under consideration by the Army based on the highly successful results of the geodetic satellite now in orbit. Under this program, the orbital altitude of the *SECOR* (for Sequential Collation of Range) satellite would be tripled from 600 miles to 1,800 miles, with a corresponding beef-up of the transponder to enhance the signal received on the ground from the higher altitude.

Army officials said that *SECOR* is being used in the Pacific to locate island masses with an accuracy of about 100 ft. in 1,000 mi. This accuracy far exceeds first-order survey requirements. Survey accuracies of land masses surrounded by large expanses of ocean prior to *SECOR* had been of the order of 5-10 mi.

● **Triangulation applied**—By increasing the orbital altitude of the satellite, both the accuracy of location of an unknown position and the distance over which it can be achieved would be increased. Through a triangulation process, the *SECOR* transponder receives ground signals from the known and unknown stations, which the transponder then retransmits back to the ground. Because of the phase shift in the signal, the distance to the satellite can be determined and the location of the unknown station calculated.

If the unknown station is below the radio horizon, the same process is used, except that the location of the unknown station is calculated from a small segment of a short arc in the satellite's orbit. Accuracy is somewhat degraded in this case. Thus, raising the orbital altitude would eliminate the necessity for this step and improve accuracy over longer distances.

The present system, which the Army says "is contributing to the scientific and the military capabilities of the United States" consists of three known ground stations located at precisely known points in Japan and the Ryukyu Islands and an unknown station on Iwo Jima.

Two other stations are being located at other points in the Pacific. By "leapfrogging" the mobile ground stations, the Army expects to precisely locate nine unknown points in the Pacific in the first year of operations.

● **Usefulness**—The most immediate military advantage likely from this exercise would accrue to the *Nike-X*, Project Defender and anti-satellite programs. By precisely locating such major R&D installations as Johnston Island (location of the anti-satellite effort) and Kwajalein Island (*Nike-X* and Defender), and tying these into the major U.S. datum, these programs would be put on a common reference.

Of longer-range military importance would be the tying together of continental datum planes. The Army now estimates that continental land masses are known to an accuracy of plus or minus one mile. With *SECOR*, this accuracy could be increased to 100 ft. or less.

Once continental datum planes are tied together, the location of critical enemy installations, such as command and control centers and missile sites, can be accurately located.

One of the worrisome problems of intercontinental warfare has been the lack of reliable and adequate surveys of the Soviet Union. Satellite mapping, however, using photogrammetric techniques, has received major emphasis in the military space program. The only remaining problem, it would appear, is to tie together the U.S. datum with the European, which, at least on one major traverse, is tied to the Soviet Union.

● **System accuracies**—Accuracies achieveable with *SECOR* were illustrated by the Army announcement last month that during tests in the U.S., the location of Fort Carson, Colo., was determined to differ from the previously accepted location by 2 ft. 3 in. in latitude, 23 ft. 3 in. in longitude and 18 ft. 3 in. in elevation.

The *SECOR* transponder was developed by Cubic Corp., San Diego, Calif., and the satellite is built by ITT Federal Laboratories, Nutley, N.J. A piggy-back payload, *SECOR* weighs some 40 lbs. and measures 9 in. by 11 in. by 18 in. It is normally carried into orbit on the aft skirt section of an *Agena* and spring-ejected into a 600-mi. orbit. The Army recently ordered three more satellites from ITT as backup to minimize the impact of a satellite failure on the program.

The satellite now in orbit—presumably launched aboard a *Thor-Agena* from Vandenberg AFB, Calif., Jan. 19—has completed more than 4,000 orbits and is still functioning. ■

Martin Testing Sprint Ejection

POP-UP TESTS to prove the cell-ejection technique for *Sprint*—the Army's newest anti-missile missile—are under way at the Martin Co.'s Orlando, Fla., plant. In addition to proving the ejection technique, the tests are to prove the design of the launch cell itself and the mechanism used to eject the missile.

A full-scale slug—similar in weight and configuration to the actual missile but minus live motors and control surfaces—is ejected, rather than flown, out of its underground cell. The dummy missile travels some 200 ft. in the air before it is restrained by tethering lines.

Ejection is achieved by use of a "hot gas generator," which, when its propellant is burned, creates enough pressure to pop the missile from its cell. By using this technique, the Army expects to be able to use a cheaper, simpler launch cell to house the missile and also to save considerable structural weight in the missile.

Sprint is designed as a high-acceleration missile for low-altitude interception of warheads after the atmosphere has filtered the decoys. Final design of the missile and the propellant combination to be used are to be finished by the end of this calendar year. No announcement of the flight test program has been made.

McNamara Firm on Conduct Code

Vance reinforces DOD resolve not to modify directive despite industry, military resentment; AOA moves to circumvent edict

DEFENSE SECRETARY Robert S. McNamara has defended the recent amendment to the Department's Standards of Conduct directive and asserted that he had "no apologies for it."

"I think all of us would agree that in defense, where we are dealing with $25 billion worth of procurement a year, that we must be as pure as Caesar's wife," McNamara said. "I think all of us want to be. That is the only purpose and intent of the directive."

This contradicted and put to rest a widespread feeling among industry and the military that, because of the outcry raised against the amendment, it would be modified before it goes into effect Nov. 24. Deputy Secretary of Defense Cyrus Vance made it clear in an interview last week that there was no intention to modify the directive.

Vance also admitted that the Department was investigating reports of "irregularities on the part of naval personnel" at the Avondale Shipyards in Westwego, La. It had been rumored that the lavish entertainment of Navy personnel in New Orleans had been the immediate cause for issuing the new directive. Vance stressed, however, that "Avondale is not the first case investigated. Others are being or have been investigated."

● **AOA ploy**—In an effort to circumvent the spirit, if not the letter, of the Standards of Conduct edict, the American Ordnance Assn. is inviting individual companies to submit names of government employees that they wish invited to that association's 46th Annual Industrial Preparedness Meeting in New York City Dec. 2.

Invitations will then be sent to these government people in the name of the association. (Associations are not covered under the amended directive, which forbids acceptance of "gifts, gratuities or entertainment" from any individual or company doing business with the department.)

To pay for government personnel attending the dinner, AOA has raised the dinner reservation price from $25 to $40 per place. This is expected to cover the cost of the association invitations to government personnel. In effect, what is planned is that if Company A reserves one 10-place table and invites three DOD officials, it would pay $280 for the remaining seven places versus $250 for all 10 places last year.

● **Move & countermove**—Ever since the directive appeared, it has raised a storm or protest and charges that DOD was impugning the integrity of military officials. Now the emphasis appears to be shifting to means of circumventing the language of the amendment. The Association of the U.S. Army, which will hold its convention in Washington this month, announced earlier it would have a hospitality lounge at which all are welcome and industry representatives foot the bill. Then AOA announced its plan.

But the last move still appears to rest with the Defense Department. As Secretary Vance pointed out, the services are writing implementing directives spelling out the "do's and don'ts" for their personnel. These implementing plans could still frustrate the association plans.

McNamara pointed out that expenditures of defense contractors on gifts, gratuities, entertainment and "favors of one kind or another" have been substantial. When he was challenged on the point of whether these expenditures were taxpayers' dollars or contractors' dollars, the Secretary's rejoinder was that "contractors are not in the business of giving away stockholders' money."

Arguing from the point of view that even if these gifts came from profit dollars, McNamara pointed out half of the costs could be deducted from taxes—thereby depriving the government of at least that amount. He continued, however, that contractors are in the business of making profits and therefore they "have got to have a price that covers their costs and covers all their costs, allowable and non-allowable." ■

European Comsat System Studied

GENEVA—Despite signing of the comsat agreement with the United States, European governments are keeping the way open for a separate satellite system of their own.

At a meeting last week in Bonn, the member states of the European Conference on Space Communications discussed their cooperation with the U.S. Communications Satellite Corp. through 1969, but also assessed the feasibility of simultaneously developing a complementary or competitive system for post-1969. No Americans were invited.

Europe is not actively planning to bolt the present agreement, but as one official told M/R, "we just want the ability to go our separate way in case the stateside people back us into a wall with a gun at our heads."

Reports indicate that tens of millions of dollars have been pledged toward the scheme, which is included in the follow-on European Launcher Development Organization (ELDO) program. This second phase of the ELDO program is expected to be approved by all member governments this month.

One of the last acts of Britain's Conservative government was to propose at an Oct. 1-2 meeting in London that a convention be signed by all the European governments following up the current ELDO/ESRO organizations with a single body to develop, launch and operate space payloads. One of the first mentioned was an all-European communication satellite. The new Labor government is understood to favor this proposal, as do most of the other governments involved.

Two Mariner Spacecraft Poised For Exploratory Trip to Mars

TV-bearing spacecraft to come within 12,000 mi. of planet's surface; second will trail first by 2-9 days; both to arrive in mid-July

by Rex Pay

THIS WEEK will see the start of an attempt to launch two *Mariner* spacecraft on a trajectory that will take them within 12,000 miles of the surface of Mars.

The earliest launch attempt will be Nov. 4. If successful, the second flight could follow on Nov. 6, but Nov. 13 is considered a more likely date. A third backup spacecraft is at Cape Kennedy, fully checked and ready to go if either other flight is unsuccessful.

If the launches by the *Atlas-Agena D* are successful, the two spacecraft will be named *Mariner III* and *IV*. Because of their trajectories, they will arrive at Mars about two to four days apart in mid-July 1965.

Purpose of the fly-bys is to take television pictures of the Martian surface with a resolution of 2.5 kilometers and to study the planet's environment.

The TV pictures will permit preliminary topographic reconnaissance of part of the planet's surface and provide some indication of the location of areas where living matter may exist (M/R Aug. 3, p. 38).

Critical information for the design of future interplanetary spacecraft will also be obtained in a planned measurement of the Martian atmosphere's characteristics (M/R Sept. 14, p. 62). Other measurements will be made of surface pressure, temperature, density and probable constitution of the atmosphere.

Previously, examination of the Martian atmosphere was to be carried out by a JPL ultraviolet photometer, the probe remaining in view of Earth throughout the fly-by. Then systems tests showed that the UV photometer arced and blanked out the television pictures during fly-by. With no time for redesign of the photometer, it was taken off the spacecraft and the occultation experiment, rejected two years previously, was selected instead.

An infrared experiment was also taken off the spacecraft when it proved to be too heavy.

● **Heavily instrumented**—In spite of these losses, *Mariner Mars* remains a heavily instrumented spacecraft. A three-axis helium-vapor magnetometer will investigate the Martian magnetic field, measuring its orientation in relation to the planet's axis of rotation. An ionization chamber will measure average omnidirectional flux of particle radiation. A cosmic dust detector will look for increases in micrometeorite flux in the Mars-Deimos-Phobos system.

Trapped radiation detectors will make directional measurements on particles, investigating energy spectra and identity. A solar plasma probe will measure spectral distribution, flux density and time history of the solar plasma flow. A cosmic ray telescope will give further measurements of trapped particle radiation.

The digital television system carried aboard *Mariner* is expected to take 20 pictures of a series of areas 200 mi. square across the face of the planet. An all-electrostatic, ruggedized vidicon is used, a 200-line raster covering a square area of 0.22x0.22 in. on the vidicon faceplate.

All instruments except the television system will make measurements during the cruise through interplanetary space.

● **Launch time**—Launch window for the spacecraft opens on November 4. Initially both spacecraft and their individual *Atlas-Agena D* boosters will be counted down together. If both are "go" a few hours before lift off, one count will be suspended. If one is launched successfully, the remaining booster count will be recycled for launch two days after the first.

Data transmitted from the two spacecraft will be tagged with identifying codes to prevent misinterpretation.

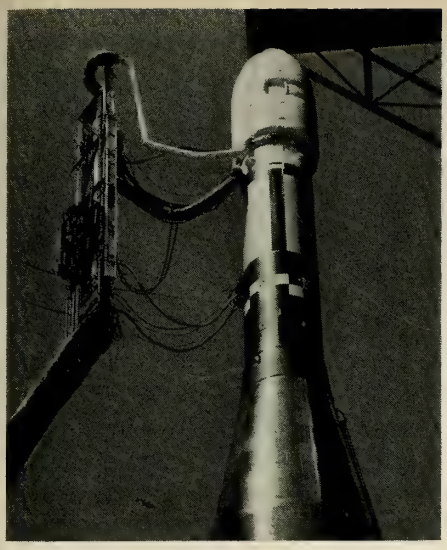
Timing and control of spacecraft operations are provided by the onboard central computer and sequencer (CC&S). Times of all commands from the CC&S are referred to lift-off, the unit itself being inhibited until three minutes before this time. After *Mariner* separates from the *Agena,* the CC&S commands extension of the solar panels and turns on attitude control power. Attitude control is provided by cold-gas jets and servo-driven solar vanes.

One or two midcourse maneuvers may be required to adjust the trajectory with the necessary precision. The CC&S accepts and stores radio commands specifying pitch, roll, and duration of motor burn. A further radio command initiates the maneuver.

Of the various pulse trains from the CC&S, a set with a repetition rate of once every 3 hours 20 minutes is used to operate a master timer and to start the planetary encounter sequence. Updating of time-to-go-to-encounter is carried out from the blockhouse prior to launch, to give a turn-on time up to 277 days from launch. Automatic termination of the encounter sequence is initiated by the CC&S after 13 hours 20 minutes.

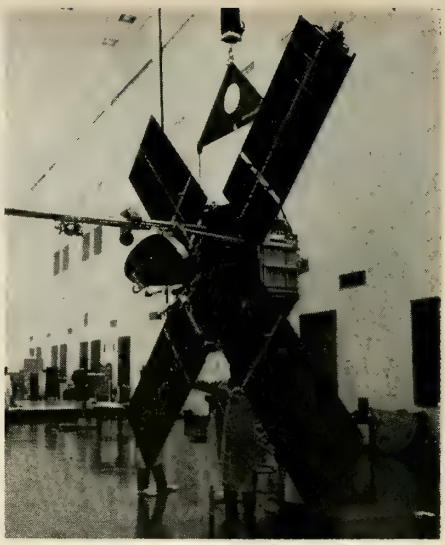
Before and after encounter the CC&S provides commands to change the Canopus star tracker cone angle, data rate, and transponder operation modes.

● **Flying time**—Flight time to Mars will vary from 7½ to 8½ months, depending on the launch data. An additional three weeks of flight beyond the planet will be needed to return data. Solar cell output from the four planets



LEFT: Mariner-Mars 64 spacecraft mounted in its shroud atop Atlas-Agena D launch vehicle at Cape Kennedy is kept at even temperature by a cooling blanket.

RIGHT: Solar panels for Mariner-Mars 64 spacecraft are attached at white room in Hangar. Four panels, each 71.4 in. long and 35.5 in. wide, are attached to top, or Sunward, side of the octagon. Solar pressure vanes, which will act as an auxiliary attitude control system during Mariner's flight, are located at outboard ends of each panel.



is expected to be 690 watts near Earth and 299 watts near Mars. Cell temperature is likely to vary from 59° near Earth to −12°C at Mars encounter.

During its flight, *Mariner* will transmit 10 million words of engineering telemetry. To reduce time and effort in scanning repetitive information, a digital computer program called the Guidance and Control Flight Analysis Program has been developed to analyze this telemetry automatically.

Configuration of the flight path is such that a fixed high-gain parabolic antenna can be used on the spacecraft. During maneuvers, an omni-directional antenna maintains communications.

• **Craft description**—Basic configuration of the *Mariner* spacecraft is an octagonal frame with a mast on top that carries the omni-directional antenna, magnetometer, and ionization detector. Attached to the frame by hinges are four solar-cell panels in cruciform arrangement. Seven of the octagon bays carry electronic equipment, the eighth carries the mid-course motor.

Main structure consists of two ring frames tied together by eight longerons. A central torque tube provides a mounting for the planet scanning platform, and a subsidiary structure supports the attitude-control gas bottle. Basic structure weighs about 30 lbs.

The planetary scanning platform is used to point the television camera at Mars. For the present flights it carries the television camera and wide-angle and narrow-angle planet sensors.

Navigation sensors carried aboard the spacecraft include an Earth detector, square root Sun sensors, re-set Sun sensors, and a Canopus sensor. The spacecraft is first locked onto the Sun in two planes and then stabilized in roll by locking it onto Canopus. The Canopus sensor uses an image dissector tube with a spherical S-11 photocathode. It has a catodioptric lens that gives a field of view of 11 degrees, which is gimballed electronically to follow Canopus through a total excursion of 28 degrees in cone angle.

• **Chance of error lessened**—By searching for Canopus by means of a clockwise roll, the probability of acquiring Achernar is reduced to 0.1. During roll, a star-brightness readout signal will indicate brightness of objects in the trackers' field of view every 1.2 degrees. This will enable a star map to be drawn up, even if absolute brightness calibration is not reliable, increasing the likelihood of identifying Canopus. As a further backup, a photo-conductive Earth sensor is located so that Earth enters its field of view only if Canopus is acquired by the tracker.

There are two data automation systems on the spacecraft to handle measurements made in the cruise mode and during planetary encounter. During cruise a real-time data automation system (RT DAS) operates; during encounter a non-real-time system operates. The NRT DAS includes a tape recorder. This enables information acquired at a high rate during planetary encounter to be stored and subsequently played back at 8⅓ bits per second (M/R August 3, page 38). Some 330 ft. of two-track 0.25-in. tape is used for recording.

The science Data Automation System controls and synchronizes the science instruments, provides the necessary instrument sampling rates, converts and encodes the various forms of science data into a suitable format, buffers science data occurring at different and sporadic rates for transfer to the telemetry encoder at constant specified rates, and interconnects the science subsystem with other subsystems. Two identical 1,320-bit core buffer memories are used in conjunction with the NRT DAS.

One function of the RT DAS is to make analog conversions of the three axes in the magnetometer simultaneously, eliminating ambiguity and enabling a reading to be taken at one point in space.

All science data taken at encounter will be played back as often as possible. Also, measurements to assist in interpretation will be transmitted in real time.

The *Mariner C* science subsystem uses an analog-to-pulse-width conversion unit at each instrument to implement the analog-to-digital conversion carried out by the DAS. This eliminates direct coupling of analog signals between the instruments, the DAS, and other uses of the DAS.

About 6 hours 20 minutes before planet encounter, power to the NRT DAS, the planet scanning subsystem and the TV subsystem will be turned on. The scanning platform then starts scanning through 180 degrees and the DAS starts sequencing the TV system, but data is not recorded.

While the platform is scanning 180 degrees in one direction, the spacecraft motion provides scan in the orthogonal direction. A wide-angle planet sensor with a 50-degree circular field of view is mounted on the platform together with a narrow angle sensor with a field of about 1.5 degrees.

The sensor used for tracking is a semiconductor junction device that indicates the X-Y coordinates of a light spot on its surface by means of a pair of voltages. A fiber optics system is used to reduce the size of the planet image. ■

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POTPOURRI

EDITORIAL

FREE STREAM MEASUREMENT PROBE

(photo enlarged 10,000 times)

Once upon a time there were two ways to check flowing stuff; you stuck a probe into it or you grabbed some as it went by. Either way—stab or grab—you ended up making an accurate analysis of a non-representative sample (where you touched the flow, creating turbulence, you changed its character). Now there's a better way. Giannini Controls, in its lust for measurement accuracy, has developed a new type of probe. It senses free stream data without making waves. *Our probe is a beam of gamma rays.*

Say, for instance, you want a precise, direct measure of air density from a sounding rocket. As a start, put a tiny radioactive source inside the rocket's skin. The source shoots a beam of gamma rays off to the side of the bird. Elsewhere on the rocket put a Giannini densitometer and focus it on the gamma beam. Then crank up your bird and fire it. It's just that simple. Honest! (doubters can find more intimate details in the far right hand column).



62 SECOND MAZE: *Synchronize your watches: you have exactly 62 seconds to get from A to Z. 3, 2, 1 . . . GO!*

Giannini Controls Corporation

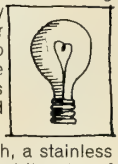
1600 South Mountain Avenue, Duarte, California

WHAT YOU GET OUT OF A MISSILE DEPENDS ON HOW YOU PUT WHAT YOU PUT INTO IT, INTO IT



Missiles with fueling problems, like delinquents, can spend a lot of time hanging around the pad, smoking. Even when they're launched, you've got to watch their drinking-habits; a missile engine running oxidizer-rich is very likely to go to pieces.

When we learned of these shocking problems, we did what any good, DOD-fearing vendor would do; we innovated-up an answer (in this case, we means Powertron, GCC's Division in charge of sound ultrasound).



The result is Sonoswitch, a stainless steel ultrasonic probe about the size of Sonny Liston's index finger. It senses liquid levels to hundredth-of-an-inch repeatabilities and doesn't care what the liquid is (LOX, LH2, N_2O_4, Aerozene, IRFNA, lighter fluid—you name it). It's equally cavalier about dielectric, conductivity, density and other fluid perplexities. Reliability is 99.99%.

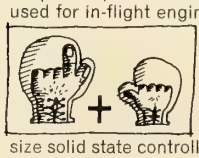




If you're accident prone, you'll be pleased to know that Sonoswitch is intrinsically safe, has no moving parts, and is unaffected by circuit or component fluffs.

On the ground, Sonoswitches are used in Powertron-designed integrated systems for all phases of fuel tanking, wherever precise monitoring of liquid level is required.

Upstairs, Sonoswitch systems are used for in-flight engine cut off. In this case, the probe is connected to a Liston's-finger-plus-one-joint-of-Cassius-Clay's-thumb size solid state controller.



The result shuts off engines and triggers stage separation when fuel depletion levels are reached.

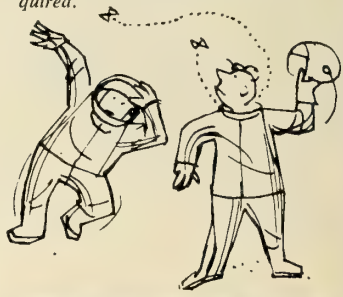
For more data on Sonoswitch probes, ask us to send literature. Or drive by Powertron at Plainview, Long Island and say "fill 'er up."

the end



GCC BUGS MOON MAN

Our friends at Ham.-Standard tell us each LEM "moonsuit" will be equipped with two GCC Model 451218 miniature pressure transducers. One of these 1" by 1" by 1" by 1-ounce sensors will be used for telemetering suit pressure data. The other, a switch output device, automatically warns the moon man to bug out when his suit pressure approaches the danger level. These "cubic inch" transducers have been thoroughly field tested as in-flight, surface mounted pressure pickups . . . in missile and space vehicle telemetering . . . on re-entry vehicles . . . and wherever small, light, accurate pressure data sensors are required.



EDITORIAL (continued)

As we left our hardy band of adventurers two columns to the left, they were in the act of firing their Giannini-equipped sounding rocket in hopes of achieving an accurate, direct measure of true air density. As the rocket soars into space, a beam of gamma rays is directed through the skin of the bird. The gamma, interacting with the air, scatters. The ratio of the gamma scatter is in direct proportion to the density of the air. The watchful densitometer, which is zeroed-in on the gamma beam, counts the rate of scatter—allowing a direct running account of air density to be made. It works on the ground, it works at 250,000 feet, it even works during re-entry (gamma rays penetrate plasma like it wasn't there).

INFORMATION

FREE: MORE POOP

Our friend, the publisher, has allotted us these reader service numbers:

10 for spec sheet on Moon Man's bug.
11 for data on free stream probe.
12 for bulletin on Sonoswitches.

Technical Countdown

ELECTRONICS

Radiation-Effects X-Ray Service Available

A 1-Mev, 10,000-amp pulsed X-ray facility is now available to industry for radiation effects studies of large subsystems. Built and now in operation by Physics International Co. in Berkeley, Calif., the test facility is said to consistently produce a maximum forward gamma intensity of 10^{30} Roentgens/sec. Radiation pulses of 30 nanosec. are typical. An intensity of 10^{9}R/sec. can be produced by the X-ray through a 40-in.^{3} volume.

Goodyear Lands EW Deployment Study

Goodyear Aerospace Corp. will pursue research and development work into highly accurate direction-finding equipment under a new contract from the electromagnetic warfare branch of the Avionics Division at Wright-Patterson AFB. The entire electronic warfare program at Goodyear grew out of discoveries at the firm's Litchfield Park, Ariz., facility. The plant produces high-resolution side-looking radar for Air Force and Navy aircraft. Developments during design of this radar system led into the ECM field.

ADVANCED MATERIALS

Thiokol Tests Beryllium Oxide Nozzles

Porous beryllium oxide throat inserts have successfully channelled exhausts from both high-energy aluminized and high-burning-rate polysulfide propellants in tests at Thiokol Chemical Corp.'s Elkton Div. A throat insert tested for 10 seconds in one firing was re-used in a subsequent 15-second test. A small amount of aluminum oxide was found deposited on the throat after the second test but no erosion was discovered. The beryllium oxide material has a density approximately ⅓ that of tungsten and shows promise for rocket motor use on a cost-effective basis. The material was supplied by the Beryllium Corp. of Reading, Pa.

PROPULSION

UTC Fires Smallest Bipropellant Device

A methane/oxygen bipropellant microrocket has been developed, built and test fired by United Technology Center. The thrust range of the device is from 0.0005-lb. to 0.1 lb., making it the smallest bipropellant fired to date. UTC experts say the device could be used to provide slight changes in space vehicle attitude.

120-in. Scale Motor Cartridge Loaded

A cartridge-loaded motor, scaled to approximately 1/20 the size of the 120-in. solid strap-on boosters for the *Titan III-C*, is being used in wind-tunnel tests at the Arnold Engineering Development Center. The models have been used in heating tests conducted by the Martin Co. to determine solid booster exhaust effects on the *Titan III-C* core vehicle. United Technology Center designed the scale motors, using materials identical to their full-size 120-in. boosters. The motor is cartridge loaded and uses replaceable plastic exit cones and graphite inserts in the nozzle.

SPACE MEDICINE

Calorimeter Tests for Toxics and Contaminants

A new research tool to investigate the effects of trace contaminants and toxic propellant materials has been completed at the Air Force School of Aerospace Medicine. The gradient layer whole-body calorimeter allows recording of changes in radiant heat loss with practically no lag time, records changes in evaporative heat loss, oxygen consumption and carbon dioxide production with short lag times, and continuous collection of urine for chemical assay. Dogs will probably be used as test subjects.

Silicone Film Seen as Air Purifier

A very thin and very permeable silicone film has been produced at the General Electric Research Laboratory for possible use as a membrane system for supplying air from water and for purification of air in space vehicles. One man's requirements could be furnished by a selective membrane about 2½ square yards, plus a compressor to remove enriched air from the low-pressure side of the membrane, GE said.

ASTRONAUTICS

Solar System Not Sterile?

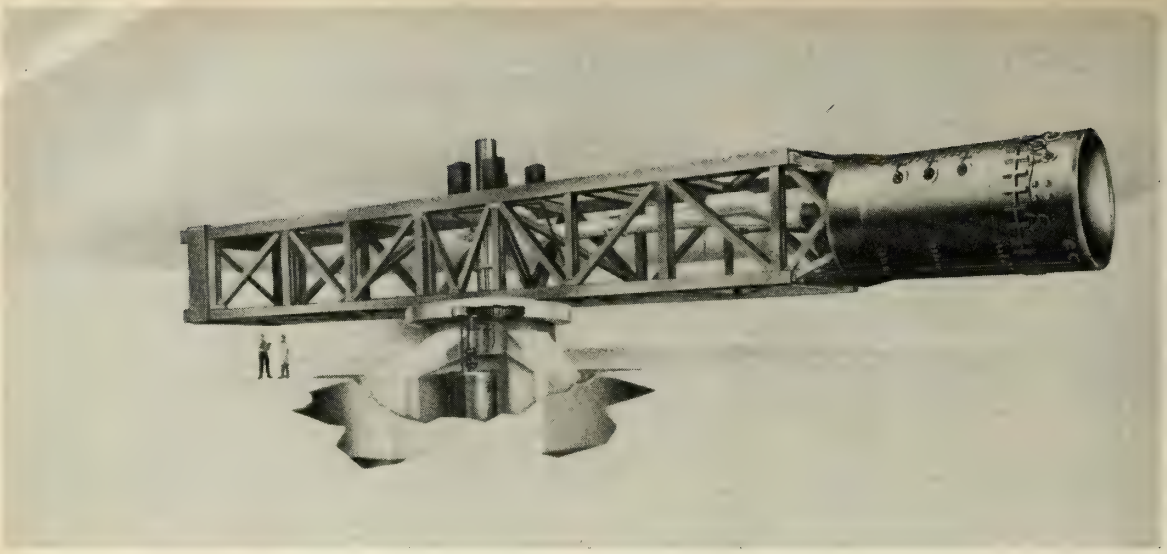
Exposure of common micro-organisms to ultra-high vacuum for more than four months in an experiment at Jet Propulsion Laboratory tended to preserve rather than kill the micro-organisms. Although this emphasizes the importance of sterilizing interplanetary probes before launch, it also suggests that cross-contamination may have occurred throughout the solar system, particularly in view of the fact that micro-organisms have also survived temperatures as low as −190°C.

Venus-Earth Distance Measured To 3 Km

Using the 85-ft. Venus site antenna and range-gated lunar radar equipment, experimenters at the Goldstone Deep Space Instrumentation Facility claim great success in precision tracking of the planet Venus. Range measurements with variations of less than 3 km were obtained. Mean tracking distance over an hour could be computed to better than a kilometer. Tests showed that Venus ephemeris was in error and that the error was changing by about 18 km per day. Variations attributable to surface features were also detected.

Voice Reflected from Venus

Speech compressed 32 times has been reflected from Venus after transmission from the Goldstone Venus site—a research and development area of the Deep Space Instrumentation Facility. Intelligible voice recordings were obtained as part of a program to evaluate relatively broad-band deep space communications.



LAUNCH-PHASE SIMULATOR under construction at Goddard Space Flight Center.

space support

NASA Center Nears Completion Of Launch-Phase Simulation Facility

Goddard device will add link to chain of simulators needed to test spacecraft from launch to re-entry

by William S. Beller

"CRADLE-TO-THE-GRAVE" testing of unmanned satellites is moving closer to reality at Goddard Space Flight Center where the Free World's first launch-phase simulator is nearing completion.

Almost any spacecraft able to fit into a *Centaur* will be capable of being tested in this new facility. The $4-million simulator is scheduled to be operational within a year.

The LPS is designed to test large, advanced satellites such as the *Orbiting Geophysical Observatory* and the *Orbiting Astronomical Observatory*. In the launch configuration, these spacecraft measure about 15 ft. in length by 10 ft. in diameter. Their weights range to almost 4,000 lbs.

Industry will undoubtedly be able to make good use of the LPS to shave pounds off satellites, particularly large ones that are often overdesigned out of respect for the combined loads created by launch. Moreover, proper performance of satellites themselves might be ensured. It is surmised, for instance, that *Ranger VI's* TV cameras failed during the launch phase—a situation that might have been uncovered and prevented had an LPS been available.

The simulator also will be used for developing spacecraft structures and scientific equipment able to survive a launch, according to Dana S. Cope, project manager for the facility.

• **Past is prologue**—The usual way to find the effects of a launch is to isolate the various expected loads and then impose them on test satellites and their subsystems. Vibration loads, as an example, might be put on a satellite by means of a shaker table. In subsequent tests, acoustic and acceleration loads might be introduced. If any of the tests are run in an environmental chamber, then vacuum conditions might also be superimposed.

The LPS, though, will subject the spacecraft to the simulataneous and varying loads of vibration, acoustic and acceleration—all while the air pressure is decreasing with the simulated launch altitude.

In this way, satellite systems can be tested as units under combined loadings to give a truer picture of the actual environment in which the spacecraft will operate.

The Goddard simulator is simply a giant centrifuge with a sealed chamber at the working end. The satellite to be tested is placed inside the chamber with

the nose or leading edge of the satellite pointing to the center of the centrifuge. The base of the satellite is connected to the detachable cap or outermost portion of the chamber. By this arrangement, the accelerations imposed on the satellite correspond in direction to those expected during satellite launch.

● **Looking like a launch**—The LPS is designed to ensure the success of NASA spacecraft scheduled for launching this decade and even a few years beyond. Typical of the spacecraft the space agency says it will be testing in this new facility will be geophysical, meteorological, communication and space observatory satellites.

To arrive at the specifications for the facility, NASA engineers analyzed scores of launch profiles for typical space vehicles such as the *Atlas-Agena B, Centaur, Thor-Agena B, Delta, Scout* and others. From this information, design parameters were chosen that would give the most flexibility in programming a launch on the LPS.

Two design parameters were not included—dynamic pressure and temperature. Both were considered, but were eliminated either because of added sophistication needed in the case of dynamic pressure, or lack of funding as for temperature.

Nevertheless, Cope believes that a five-minute test run on the LPS will come close enough to actual conditions to be adequate for nearly any mission. Runs up to 30 minutes can be programmed. Cope discounts both the effect of the 1-g vertical bias on the spacecraft due to the centrifuge swinging in a horizontal plane; and the inability to simulate the sudden changes of acceleration at points such as at liftoff and in staging.

Cope feels that the horizontal bias is too small to worry about. He also says that the programmed acceleration curves will include as end points the highest g-loadings reached and therefore should be a satisfactory simulation of these conditions.

● **Operation**—Northrop Corp.'s Marine Equipment Dept. has the contract for the entire LPS except the drive system, which is being built by Allis Chalmers. This drive system is to deliver dc power to two 1,250-horsepower drive motors, which can be increased to four drive motors in an expanded system. The entire system will be capable of 100% overload for five minutes, in this way doubling its capacity for a launch profile.

The rotating arm of the centrifuge turning at its maximum design speed of 33.5 rpm will be able to sustain a 22.9-g acceleration at the test radius of 60 ft. The reason for the relatively long arm is to keep small the centrifugal-force gradient in the spacecraft under test.

The arm structure will be a truss composed of conventional structural steel elements. It will be mounted with appropriate bearings on a steel-concrete pedestal. The arm system is described as including vacuum lines paralleling the main chord members and connected to a vertical manifold extending downward into the pedestal at the center of rotation. Power, instrumentation, and control wiring will connect to slip-ring systems at the axis of rotation.

The test chamber will have the general shape of a cylinder. Its head, or the entire chamber, will be removable from the arm. The internal test space will hold one 10x15-ft. spacecraft plus a shaker system and other accessory equipment. Future plans call for equipping the test chamber with a rugged television camera to permit continuous observation of the spaceflight unit tested inside the chamber.

● **Environmental systems**—The test chamber will contain a steam-driven air-ejector evacuation system. The vacuum system will be able to reduce chamber pressure from surface ambient to about $3x10^{-4}$ torr (equivalent to about 200,000-ft. altitude) in a pressure profile close to that occurring in an actual launch.

Extended vacuum levels will be maintained by a mechanical holding pump located next to the ejector.

A vibration table will be mounted on the inner face of the removable outboard head of the test chamber. The base of the spacecraft will be attached rigidly to the inboard face of the table so that the test chamber head, the vibration table and the spacecraft will be capable of being handled as a single package.

Programmed vibrations will be fed into the test chamber by means of hydraulically actuated force generators. These will put in either sinusoidal or random vibrations in three degrees of freedom: along the thrust axis, lateral translation and lateral rotation.

Sufficient force will be generated by this system to impart desired vibrations to a 5,000-lb. load (4000-lb spacecraft plus 1000-lb. adapter) while it is being subjected to accelerations up to 10 g's. It will impart similar vibrations to a 600-lb. load at accelerations to 30 g's.

● **Noise**—The acoustics system includes a noise generator operating through an acoustic horn at the inboard end of the test chamber, and a tubular shelf surrounding the spacecraft within the test chamber. Compressed-air tanks located on the arm structure adjacent to the counterweight will supply air for the noise generator.

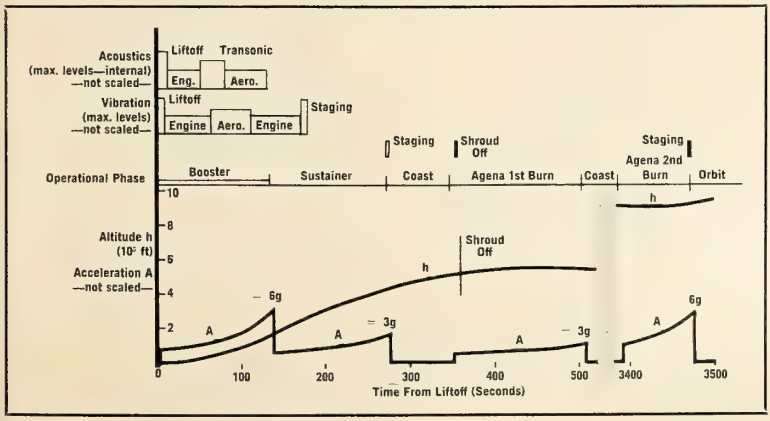
This system will be able to simulate the acoustic vibration profiles similar to those the spacecraft will experience during an actual launch. Thus, the system will be capable of producing an overall sound-pressure level of 150 db RMS at 760 torr, and 140 db RMS at 100 torr, providing gaussian random noise within the chamber in any one-third octave from 100 to 12,000 cps.

Handling equipment for the LPS will be a LPS loading vehicle. It will be used to load, unload and transport the LPS test assembly, which consists of the outboard section of the test chamber with the spacecraft attached.

The vehicle will be capable of transporting loads up to 50,000 pounds and of positioning loads up to 40,000 pounds. It will be equipped with positioning mechanisms capable of imparting 6 degrees of freedom: forward and reverse, transverse, up and down, yaw, pitch and roll.

The general configuration, dimensions and built-in safety factors of the LPS will permit future modifications such as increased drive power for heavier test payloads or, possibly, faster onset; additional environments, and more complex and refined instrumentation. ■

REPRESENTATIVE launch profile for Atlas-Agena B vehicle (EGO profile; payload, 1,000 lbs.).



Arma Div. Faces Toughest Decision

Onetime $100-million-a-year group must restore profits on defense business now expected to shrink to $21 million

by Michael Getler

GARDEN CITY, L.I., N.Y.—Within the next six to eight months, the directors of American Bosch Arma Corp. are expected to face a crucial decision—can its once thriving Arma Div. be operated profitably on a much smaller level of business, or must it be shut down as a profitless defense plant?

In brief, the history of Arma Div., and its slide to the brink of unprofitability, looks something like this:

In 1961, riding high as prime contractor for the *Atlas* 107A ICBM inertial guidance system (a program worth more than $200 million) and the B-52 fire control system, Arma sales hit $95.7 million and employment peaked at about 5,700 persons. By 1963, the B-52 business was gone, the *Atlas* business was sharply reduced, and sales were down to $43 million. Sales for 1964 are expected to be about $28 million and the projection for 1965 is for $21 million.

The work force is now down to 1,100, and an additional 100-300 layoffs are expected before the end of the year. The firm will evacuate its half-million-sq.-ft. plant here by Dec. 1 (hoping to sub-lease it), and move into nearby quarters about 75% smaller.

The chief executive of Arma's parent company, the American Bosch Arma Corp., Charles W. Perelle, told MISSILES AND ROCKETS in an interview last week that he would resign his position after the corporation's annual stockholder meeting in May. Perelle has been the chief executive at ABA for the past eleven years.

He points out that the reasons for Arma's slide relate to many things, not the least of which is the general decline in defense spending. However, he said, there were two particular "crunchers" for Arma.

● **Twin blows**—Perelle stated flatly to M/R that Arma had actually won the competition for two major missile and spacecraft guidance systems—the Air Force's *Titan III* and NASA's *Gemini*—and that the selections in both programs (made by the AF on *Titan III*, and McDonnell Aircraft Co., prime contractor for *Gemini*) had been overturned by the Dept. of Defense and NASA hierarchy. "Sure we had our five-and ten-year plans just like everyone else," Perelle states, "but they went out the window with two telegrams."

The combined business from both programs involved in excess of $200 million. The *Titan III* award to Arma was actually announced by local Congressmen, Perelle recalls. He calls that reversal "the first TFX," referring to the alleged reversal of that military competition decision by DOD.

"Whether your name is Boeing or Arma," Perelle told M/R, "doesn't matter. You've lost $10 million or $1 million in demonstration hardware costs, the business, and tied up your top talent. There, of course, is no reason to be sore if you've lost the competition. But when you win it, and you've been dealing with the service all your life, and then the rules are changed, it's hard to swallow."

Though Arma's sales have been slipping for several years, it is only this year that the profits have completely disappeared, and, as Perelle warned an Arma management group recently, "management closes plants only when no profits are in sight."

● **New business**—Whether Arma can escape this no-profit burial depends essentially on the firm's ability to cut itself down from a $100-million-a-year division, spawned in the high-cost high-urgency era of the late fifties, to one able to compete in a new defense business environment and adjust its costs and operations to a level of sales roughly one-fifth that of its recent past. "The question is can we operate at this level and make a profit? We don't really know that now," says Perelle. "We should in six or eight months."

Officials admit that there are no large systems coming up, and the firm, which has never been in the components business, is in it now almost exclusively.

This components and subsystems business could spell the difference in Arma's longetivity, and there are some encouraging signs. Perelle points out that the firm has had a relatively stable $10-million annual business base in studies and various smaller awards, and that if this can be expanded with another $10 million in subsystem and component work, the firm could be put back in the black.

To back up his optimism, Perelle cites figures which show that in 1963 the firm had about $6.5 million in business other than the big-system contracts, that it now has $9.9 million and is projecting $18 million for next year. Though the readjustment has been painful for Arma, Perelle sees "a leaner, more aggressive" organization.

Among the new business gathered by the firm:

—Arma has just been notified of an award by the neighboring Grumman Aircraft Engineering Corp. for the LEM Caution and Warning System.

—The firm has a Navy contract for development of a prototype Submarine Safety Monitoring System, which, if produced in quantity, could mushroom into substantial sales.

—Several months ago, the firm received a go-ahead for production of low-cost gyros for the Army's *Lance* tactical missile, and also expects to receive an initial order for 200-300 land navigation systems for the Army early next year.

—It has also just been announced that Arma has been selected by Piasecki Aircraft Corp. as a team member for armament and GSE for the Army's new armed helicopter study.

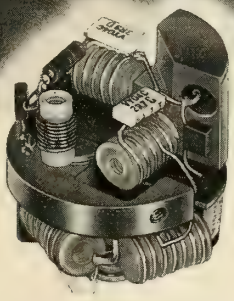
—Prototype units of the firm's G-16 "Dynatune" gyro have also reportedly been sold to several agencies in the U.S. and abroad for evaluation.

Perelle stresses that whatever the future holds for Arma, the firm is committed to delivering on all contracts.

Arma Div. is one of six within ABA, and until this year the defense business it represented was the major part of corporate sales. Though total corporate sales and profits have also declined in recent years, the firm still operates at a profit and Perelle predicts important gains for the next few years. ABA, under Perelle, has become a debt-free corporation that has invested more than $10 million, paid out of earnings, into plant modernization in recent years. Perelle believes this will begin to show an effect in 1965 and 1966. ■

ELECTRONIC SURVIVAL
1000 to 250,000 G

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Gemini's Horizontal-Ejection Escape System Reported More than Adequate

Weber Aircraft, system designer, believes it can also be used with boosters bigger than Titan II; system details

by Willard E. Wilks

BURBANK, CALIF.—The *Gemini* crew escape system has posed some special problems for its designer because it is the first system to require horizontal rather than vertical ejection of pilot seats.

Horizontal ejection with the rocket-propelled seat is necessary to clear the astronauts of the flame-ball area in the event their *Titan II* booster explodes. Results reported by the system designer, Weber Aircraft Corp., show there is every expectation that horizontal ejection will protect the *Gemini* astronauts.

However, there is some skepticism about its use with spacecraft utilizing larger boosters, and the Air Force, with *Titan III* launches of its *Manned Orbiting Laboratory* (*MOL*) downstream, is looking into the possibility of using an escape tower with *Blue Gemini* instead of pilot ejection.

"If the whole *Titan III* exploded at once, it would be a tremendous blast, and some people think the pilots couldn't get away from the pad far enough and fast enough with horizontally ejected seats," a spokesman told MISSILES AND ROCKETS.

But engineers at Weber, one of the largest manufacturers of passenger and pilot seats for airlines and the military, believe the *Gemini* escape system could be improved to cope with much larger booster explosions than the *Titan II* vehicle for *Gemini* will produce. Weber studies show seat ejection could land the crew 4,000 ft. from the pad, the added distance being gained by use of additional rockets on the pilot seat.

For the *Gemini* program, horizontal ejection appears more than adequate. The requirement is for the pilots to be landed under an open parachute beyond the 500-ft. fireball area in a zero-zero pad ejection. Tests of the Weber system have landed dummies safely as far as 1,100 ft. from the pad. Most tests land dummies in the 700-1,000-ft. range. Maximum altitude reached in the zero-zero condition, from a 150-ft. tower, is 450 ft.

● **Center of gravity factor**—An escape tower rescue, with pull-off of the entire crew capsule upward and to the side, is relatively simpler in regard to the center-of-gravity problem when thrust is applied.

"Basically, the *Gemini* seat ejection poses the same problems that are encountered with ejection from aircraft, except that it is far more critical due to the horizontal ejection from the capsule," a spokesman said. "For a horizontal ejection, if you have a lateral misalignment, the astronaut could be tumbled and driven into the ground."

Thus the relationship between the center of gravity of the seat-man combination and the thrust line of the escape rocket becomes all-important in the *Gemini* escape system. This relationship is complicated by the fact that the seat-man c.g. shifts as the man slumps under the acceleration of the explosive charge, which drives the seat from the capsule, and that of the 8,350-lb.-thrust seat rocket.

In the ballistic phase of the ejection sequence, when the explosive charge drives the rail-mounted seat from the capsule, the pilot will be loaded with 22 g for mere milliseconds. Maximum for the rocket phase is 16 g.

Static c.g. of the seat-man combination has been determined for each *Gemini* astronaut in Weber's c.g. fixture, utilizing a basic formula developed for the purpose.

The c.g. is determined in three planes. If lines representing these measurements intersect in a point, the determination is perfect. Usually, a small triangle results, and size varies among astronauts, since individuals "slosh" differently, depending upon muscle tone and other physical characteristics.

Weber has found that the dynamic (under acceleration) c.g. of the seat-man combination shifts down about ¾ in. The perpendicular distance between the seat-man combination c.g. and the thrust line is the eccentricity, and object of the escape system design is to maintain a certain eccentricity regardless of the size of the astronaut. This results in a c.g. window that is oval-shaped, about 1¼ in. long and ¾ in. wide.

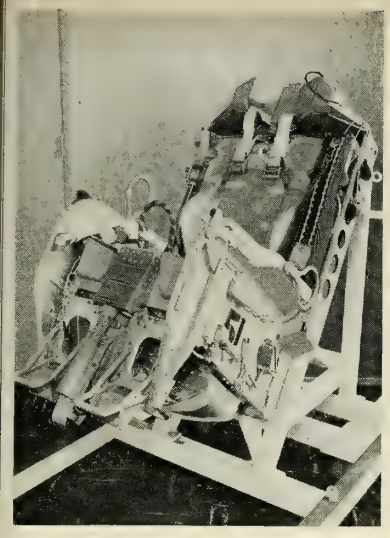
Weber has conducted tests with the thrust line farther from the c.g. than this window allowed and found that the system still functions.

● **Custom-contoured**—In order to keep the dynamic c.g. where it should be for successful ejection and flight from the vehicle, seats have been individually tailored for the astronauts through use of three contoured inserts for the back and buttock areas. Size, shape and position of the inserts are different for each man, so that the smaller astronaut sits higher than the bigger man and both have about the same c.g. system when utilizing the seat. Each *Gemini* astronaut has his own set of contoured inserts.

To properly fit each set, Weber makes precise plaster casts of each astronaut, using X-ray photos to determine optimum spine position. To supervise final production of the plaster casts, the firm employs a professional sculptor.

The main reason for contoured seats in the *Gemini* program is not the launch condition but the need to keep the c.g. where it belongs.

Weber engineers learned on the first





LEFT: Gemini ejection seat used by Weber for qualification testing. ABOVE: Buttock and back impressions of astronauts Virgil Grissom and John W. Young, scheduled to make first manned Gemini flight, shown in plaster casts on shelf at Weber Aircraft, Burbank, Calif., where similar casts of other Gemini astronauts are also stored. Molds are made by having astronauts wearing pressure suits sit in wet treated sand, into which plaster is then poured. Result is a replica of astronaut's backside, running from shoulders to slightly below the knee.

few tests of development seats that aircraft seat-ejection design couldn't be applied wholly to the spacecraft problem. The first seat tested was destroyed by rocket exhaust flame. Solution was to line the flame bucket with an asbestos material. The second seat test also ended disastrously when the parachute wrapped around the dummy's arm and failed to open. Solution was to use a drogue gun to pull out the parachute instead of the conventional spring-loaded pilot chute, which wouldn't function for *Gemini* ejection.

It also was found that the conventional Air Force automatic lap belt was unsatisfactory for a number of reasons —including the fact that the dummy opened it manually during flight. Also, because of the seat's high sides the lap belt interfered with the seat-man separation phase; Weber chose a three-point release system similar to that used in the one it designed for the B-52 ejection seat.

Another difference is that the solid-rocket motor utilized in the *Gemini* seat is placed inside the back of the seat structure, placing it closer to the c.g. and yielding a more advantageous nozzle angle. Capsule space limitations also were a consideration.

The seat rocket is procured from Rocket Power, Inc. It has a titanium case 46 in. long, with an outside diameter of 3¾ in. Burn time is 0.27 sec. Thrust is 25% more than that of the rocket used in the F-106 ejection seat. Prior to ejection the rocket tube fits tightly inside another cylinder. The two are driven apart by an explosive charge in the bottom of the outer tube.

Basic material for the seat is aluminum, but a considerable portion is made of titanium for strength with less weight.

Weber will deliver 13 ship sets, or 26 seats, under its subcontract with McDonnell Aircraft, *Gemini* capsule prime.

● **Escape and survival system**—The escape and survival system consists of the seat and means for initiating ejection, the hatch actuator system, the rocket catapult, the egress kit, the integrated harness release system, the seat-man separator, the ballute system, the drogue mortar, parachute system and survival kit.

The egress kit is contained in the astronaut's contoured seat cushion and carries his bail-out oxygen. The back pack carries the parachute and survival kit. Foamed-in-place plastic within single-piece metal structures is utilized for the contoured inserts.

The system is designed for ejection and parachute deployment from the capsule while *Gemini* is on the pad and until an altitude of 89,000 ft. and velocity of Mach 3.3 is attained. It can withstand ambient temperatures of −65° to 200°F. It is also designed for ejection and deployment from the capsule while the vehicle is paragliding, or from the capsule should the paraglider malfunction.

Ejection is initiated when either astronaut pulls the ejection control located between his knees, resulting in mechanical and ballistic actuation to automatically: open the hatches; eject the astronauts, seats and survival equipment; separate astronaut and survival equipment from the seat; provide bail-out oxygen; provide astronaut stabilization in free fall; and deploy recovery parachute. Below 9,000 ft. the sequence is completed in about 4 sec.

The seats and men separate 1.1 sec. after ejection; at 3.8 sec. the drogue gun fires to extract the pilot chute and deploy the 28-ft.-dia. main parachute. The two ejection seats are identical in operation.

● **Ejector operation**—Pulling of the ejection control fires an initiator that ignites a mild detonating fuse train attached to the capsule structure. This in turn fires percussion primers, which ignite the propellant in the hatch actuators. The high-pressure gas thus generated powers latch tripping plungers, which release hatch locks. As the plungers approach the end of their stroke the gas is vented through a port to power the hatch actuator pistons, opening the hatches to the locked-open position.

Gas from the hatch actuators fires the percussion primers, which ignite the catapult booster in the rocket catapult, and initial booster thrust propels the seat up fixed rails that are 50 in. long. After 38 in. of travel along the rails, the rocket motor ignites.

Movement of the seat along the rails pulls four lanyards attached to the capsule structure and components of the ejection seat.

On its rails in the capsule, the top of the seat is tilted up from the horizontal by 8 degrees, 20 seconds. The seat rocket nozzle is tilted from the center line of the catapult by 33.5 degrees, for a trajectory more than 41 degrees from the horizontal.

Separation of the astronaut and survival equipment from the seat is accomplished by an actuator piston from which high-pressure gas is by-passed to actuate a firing mechanism and a 0.05-sec. delay cartridge in the seat-man separator thruster assembly. The thruster piston pulls the seat-man separator strap assembly taut and forcibly separates man and seat. ■

First Flight of ELDO Booster T/M Components Due Next August

Netherlands firm developing system for Europa I vehicle; first orbiting of operational satellite set for October, 1966

by Frank G. McGuire

GENEVA, SWITZERLAND—First flight of airborne components of the ELDO satellite booster telemetry system is expected around next August, with full system tests expected about two months later.

ELDO (European Launcher Development Organization) flight-test vehicle *F-4* will carry the airborne components as a passenger before attempts are made to use the full system operationally on the *F-5* and *F-6* boosters slated for launch sometime after Nov. 1, 1965, and May 1, 1966, respectively.

First orbiting of a live satellite is due after Oct. 1, 1966.

Currently under development by N. V. Philips Telecommunicatie Industrie, of the Netherlands, the ELDO telemetry system will monitor the third-stage performance of the *Europa I* vehicle with 256 test data. These data will be sent to two ground receivers in an 8-bit code by two 5-watt transmitters operating at 136/137 mc.

L. R. Bourgonjon, of Philips, says one of the transmitters will use phase-reversal modulation and the other will use frequency-shift modulation.

Philips is developing and supplying both transmitters and the encoder for the rocket stage, as well as equipment for the receiving stations, antennas, servo equipment, decoders and recorders.

A time multiplex system is being used to carry the test data, and 96 inputs are successively scanned 20 times a second with the aid of a commutator, while the lower priority test points are scanned by a sub-commutator method at a lesser rate—some 4 to 16 times slower.

Design of the equipment is such that the number of inputs and the scanning speed can easily be changed, permitting adaptation of the system for other applications.

As described by Bourgonjon, the pulse-code-modulation approach was chosen to make maximum use of the available transmitter power. Variable-amplitude pulses constituting the commutator output are fed into an analog-digital converter, which changes the amplitude level into a 7-bit binary code.

Error resulting from this quantizing process is less than 0.4% for a 7-bit code, Bourgonjon says, and the RMS value of the error is 0.23%. An eighth bit is added to the code to permit a parity check on interference-free transmission to be made at the receiving end.

With each input channel measurement converted into a group of eight binary pulses, a synchronization signal is added to indicate the beginning of a commutation cycle. The signal is a 32-bit code specially formed to be recognized by the receivers.

The cycle of the commutator is therefore 32 bits, followed by 124 groups of eight, a total of 1,024 bits. With this "frame" of 50 ms, the bit rate of the system is 20,480 per second.

The number of input channels can be increased through sub-commutation, but the basic information capacity of the system remains unchanged at 124 x 7 x 20 = 17,360 bits per second. The additional bits in the total signal consist of the synchronization signal and the parity bits used to check transmission. Signals arriving at angles greater than 10° to the horizon can be received.

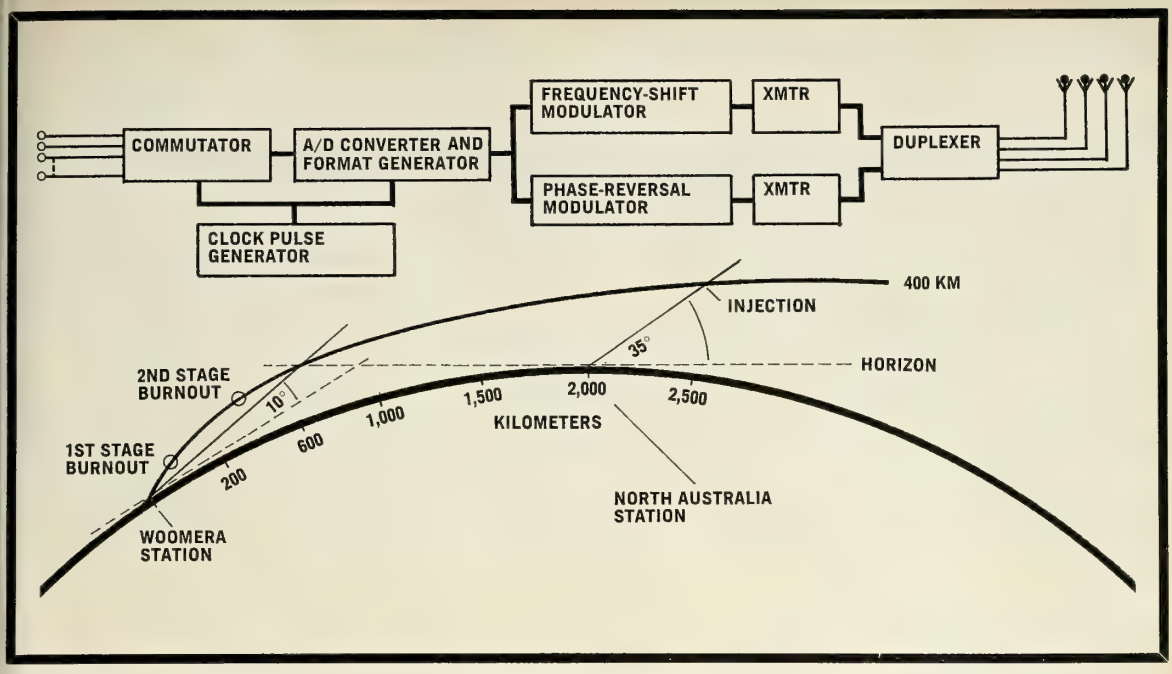
- **Modulation**—Phase-reversal was selected as a modulation method, Bourgonjon points out, because it is the optimum method for binary information disturbed only by white noise.

Since other interference caused by multi-path propagation and hot gases from the rocket exhaust will affect the signal, the *Europa I* will carry a second transmitter in the third stage using frequency-shift-modulation.

Both transmitters will handle the same information, and post-mission analysis of the results is expected to show if the 2-db advantage theoretically held by the phase-reversal method is proved in practice.

- **Range**—Initial mission of the *Europa I* will be orbiting of payloads at low altitudes, giving maximum telemetry ranges of about 1,500 km. The advanced ELDO program, however, involves distances up to 10,000 km or more.

ELDO's choice of the 136/137 mc band for telemetry makes it mandatory to include allowances for a sensitivity corresponding to a noise temperature of about 1,000°K. Receiver sensitivity is limited by cosmic noise, and transmitter power—limited by permissible weight and power consumption—can be set at



TOP: Block diagram of ELDO telemetry transmitters in third stage. BELOW: Typical flight profile of Woomera launch.

5 w maximum—a power that can be generated on 137 mc with transistor circuits.

An omnidirectional antenna will be used because of the inconstant factor of vehicle attitude relative to ground stations.

The receiving antenna gain and the bit rate are mutually dependent, and Philips cautions that the bit rate will have to be reduced for missions involving great distances. For a 20,000 bit rate from distances involving synchronous satellites, the receiving antenna would have to be well over 60-ft. dia. For lunar distances with such a rate, the diameter would increase to well over 300 ft.

● **Airborne portion**—Third-stage equipment to carry out the described telemetry job will consist of a commutator, an analog-digital converter, a format generator, and two transmitters with associated modulators. The commutator is all-electronic; the range of each input channel is 0-5v, converted into 7-bit code in the analog-digital converter; and the parity bit and the frame synchronization code are added in the format generator.

All the switching functions in the airborne portion of the system are handled by pulses derived from a crystal-controlled pulse generator, thus giving a great deal of stability to the system. Transmitters are also crystal-controlled.

The airborne system is completely transistorized and all digital circuits are thin film types based on techniques developed by Mullard Ltd.

Outputs from both transmitters are taken to an antenna system consisting of four elements distributed around the circumference of the rocket exterior in turnstile fashion. The resulting radiation pattern is as near as is possible to the isotropic.

System operation in initial flights will be about 20 min., and so a relatively small battery will supply power. Total system weight is 29 lbs.

● **Ground gear**—Telemetry stations receiving vehicle data are designed to operate effectively even with the signal-to-noise ratio at its lowest value, with the limiting factor thus becoming cosmic noise.

Regeneration of received signals degenerated by noise is possible in binary systems if the signal can be determined simply to be a 0 or a 1. If the S/N ratio drops below the minimum acceptable level, the regenerated signal is no longer identical with the transmitted signal, and the quality is therefore dictated by the number of errors occurring in regeneration.

For example, the bit error probability with an S/N ratio of +4 is approximately 10^{-2} while the error probability with a ratio of +8 is closed to 10^{-4}.

Two separate means, amplified and combined, are used to receive the two directions of polarization via an antenna made up of groups of dipoles at right angles to each other. The array has a gain of about 20 db, and can be trained on any point through use of two mutually perpendicular axes of rotation.

The rotation is actuated by servo motors controlled by an automatic tracking system. Directional information is derived from received telemetry signals or from a readout of guidance equipment.

The guidance and telemetry equipment are completely separate systems being developed by different companies in several countries.

● **Multiple receivers**—Since signals from the third-stage telemetry system and the satellite itself must be received on the same equipment, a number of receivers is required at each ground station. Seven receivers will be installed at the station in North Australia, and will be connected with the antenna by means of hybrids and preamplifiers.

Three tape-recording units will be installed at the ground stations to preserve data for post-launch analysis. Two of these will record the regenerated signal in digital form and one will record the signal before it is detected. The last is a precaution guarding against malfunction in a circuit of the detection or regenerating equipment.

In the South Australian station, a selected number of channels will be displayed immediately to give a real-time indication of launch behavior of the vehicle. Checkout equipment will be included to monitor the entire system through pre-launch tests as specified. ■

Suit Cooling System Cuts Sweat Rate

by Heather M. David

PRELIMINARY development of a novel spacesuit cooling system which could ease the physiological strain on astronauts has been completed at the Garrett Corp.

The system, which Garrett engineers describe as Internal Thermal Environment Management, or ITEM, has a considerable advantage because it does not require the astronaut to perspire to keep cool. According to Edward C. Wortz, one of the developers, the technique more closely resembles the normal cooling modes of man than do some of the other methods considered.

Even in crude preliminary tests, the company says, a reduction of more than 65% in the sweat rate was obtained. Ever since the *Mercury* astronauts suffered severe dehydration, physicians have clamored for a system which does not impose such a heavy sweat requirement.

The technique differs from the *Apollo* cooling system, which relies on conductive cooling methods through the use of water circulated in tubing throughout the undergarment (M/R June 22, p. 31). The *Gemini* spacesuit cooling system, like that in *Mercury*, is managed outside the suit through the environmental control system.

Wortz told M/R the company-funded Garrett system is not tied to any particular suit and could be incorporated into any of these.

● **Description**—The system relies on a number of liquid-to-gas heat exchangers in the gas stream inside the pressure suit. Several configurations—with the heat exchangers either attached to an undergarment or worn like a harness—have been studied. With maximum heat loads, Wortz said, about seven heat exchangers probably would be used.

Entire weight of this system is about three pounds. Wortz noted that a considerable power saving could be obtained with it, since the cooling stream is circulated at a rate of only about 4 cfm, compared with as much as 25 cfm in other systems.

Cooling gas enters the suit normally, cools the skin, then passes over a heat exchanger and is itself cooled. Moisture is continually condensed and re-evaporated, removing great quantities of heat.

The internal heat exchangers have two important effects, Garrett engineers report. One is the "cascade" cooling of the ventilating gas stream, in which the oxygen enters the suit and passes over the subject's body until it reaches about an 85°F temperature. Temperature after passing through the heat exchanger is about 55°.

The other effect, perhaps even more important, is the addition of a small amount of moisture to the ventilating oxygen flow. The condensation and evaporation cycle accounts for a major portion of the cooling process. Improvements could be made in the system by providing wicking arrangements to carry the condensed moisture away from the heat exchangers so that it may be re-evaporated, and the more times the water is recycled, the more efficient the system, Garrett engineers point out.

● **Testing program**—About 15 subjects were tested during the development of the system. The heat exchangers were placed on the subjects, who were then carefully assisted into Mark-IV Navy pressure suits. These pressure suits were also covered with a layer of aluminized Mylar, to eliminate radiant heat exchange.

The heat exchange tests were conducted in Garrett's AiResearch R&D laboratory high-altitude chamber at reduced pressures. The subjects were instrumented for medical monitoring, metabolic rate measurements, and parameters of the cooling system. During the test, the subjects mounted a treadmill, and performed at high work loads, until a stable heat load was obtained.

A number of variables were modified during the development of the system, including pressure, dew point and flow rate of the ventilating gas, temperature, and flow rate of the coolant, pressure of the cabin and differential between suit, cabin and the work load.

Without the heat exchangers, the engineers say, an astronaut generating 1,100 Btu/hr metabolic heat would have to have a sweat rate of about 24 lbs. a day. This is on the assumption that a typical pressure-suit situation would have a system with a cooling flow of 12 cfm at 3.5 psi, producing a temperature of 55°F in the gas entering the suit, and 85°F leaving the suit—removing only 10% of the heat load as sensible heat. Thus 1,000 Btu/hr. would have to be removed as latent heat.

Several configurations have been tested during the evolution of Garrett's work. The first developed removed 430 Btu/hr. from the suit when the subject had a metabolic rate of 1,000 Btu/hr. Another removed 485 Btu/hr, and a third 750 Btu/hr. Respective pressure drops in the coolant loop were 10, 13 and 14 psi respectively.

Garrett began development of the system about three years ago, and has continued company support since.

The problem of dehydration of the *Mercury* astronauts also has figured in a scientific controversy—whether the orthostatic hypotension or blood circulation condition which befell Walter M. Schirra and Gordon Cooper was a true product of weightlessness or of the dehydration itself. Solution of this problem through proper engineering of spacesuit cooling systems would not only make obvious contributions to the welfare of the astronaut, but would aid in discovering the real effects of weightlessness. ■

GD/A Picks Subs for One-Year Support System

SUBCONTRACTORS for the "optimized" one-year life-support system have been announced by General Dynamics/Astronautics. They are: Hamilton Standard Div., United Aircraft Corp., CO_2 concentrator and water recovery system; Thompson Ramo Wooldridge Electromechanical Div., CO_2 reduction unit and cabin air water separator; General Electric Missiles and Space Division, water electrolysis unit; MRD division, General American Transportation Corp., catalytic burner and waste-management system; Electric Boat Div., General Dynamics Corp., filtration water recovery system; Whirlpool Corp., Systems Div., food management system.

The G/D system (M/R, June 15, p. 35) is under development for NASA's Office of Advanced Research and Technology, and will be delivered to the Langley Research Center. It is designed for life support for four men, with resupply every 90 days.

First Saturn V Guidance Computer, Data Adapter Prototypes Due at Marshall

by Charles D. LaFond

THE FIRST *Saturn V* guidance computer and data adapter prototypes will be delivered to NASA's Marshall Space Flight Center this month.

Representing a marked advancement over its predecessor employed in *Saturn I*, the International Business Machines Corporation-developed subsystems reportedly have an expected 99.7% reliability for 250 hours of operation.

To be used with the highly advanced Bendix Corp. inertial guidance platform in the *Apollo* lunar-mission booster, the digital computer and adapter units will perform checkout and provide navigational and engine control inputs for the *Saturn V* from pre-launch to lunar trajectory injection and final separation.

Under contracts totaling $70 million, IBM's Federal Systems Div. will provide Marshall with six prototypes and 30 production models of each subsystem.

Weighing approximately 250 pounds, the two units will occupy about 5½ cu. ft. of the instrument unit, located between the *Saturn V* upper stage (S-IVB) and the *Apollo* spacecraft modules.

Of the six prototypes, two will be retained by IBM at Owego, N.Y., for testing, one will go to Cape Kennedy for use in training and three will be sent to Marshall for test and breadboard use with *Saturn IB* and *V* subsystems. First flight test will be aboard a *Saturn IB* as active systems in late 1965, according to Marshall officials.

● **Checkout and control**—The new *Saturn V* digital computer and data adapter subsystems function in four primary modes of operation: pre-launch checkout, boost guidance, orbital checkout, and lunar-trajectory injection.



SATURN V DIGITAL computer, developed by IBM, is readied for delivery.

The data adapter serves as the two-way interface between the computer and all the other guidance subsystems, either on the ground or in the vehicle. These include inputs from the ground control computer, radio command channel, telemetry computer-interface unit, and both inter and intra-vehicle communications plus the vehicle's power source, inertial guidance platform, and flight-control computer.

During pre-launch checkout, the computer is programmed to perform self-test and then a complete mission simulation and a system test.

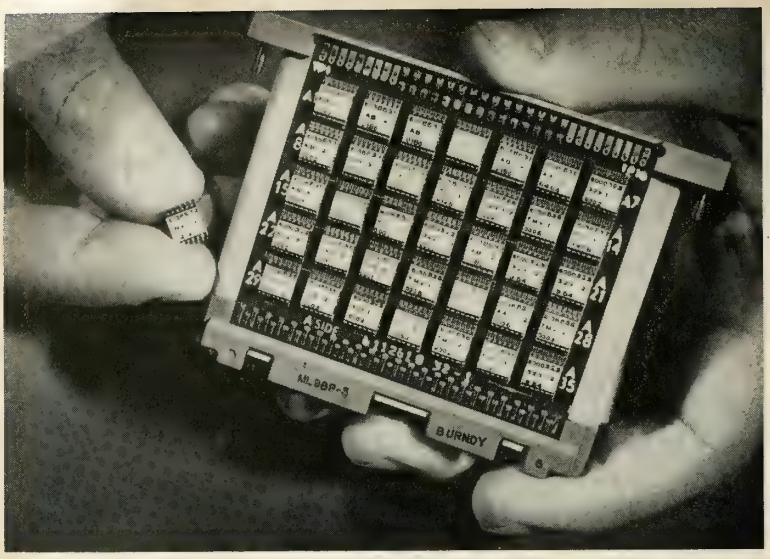
EQUIPMENT COMPARISON
(Saturn I and V Computer/Data Adapter Subsystems)

ITEM	SATURN I	SATURN V
No. components	12,000	80,000
Weight (lbs.)	210	253
Volume (ft.^{3})	3.9	5.5
Total power (watts)	540	438
Operations/sec.	3,200	9,600
Storage capacity (bits)	100,000	460,000
Reliability (MTBF, hrs.)	750	45,000

The boost-guidance mode begins with *Saturn V* lift-off, follows and evaluates in-flight booster velocity and position change inputs from the inertial platform and develops and directs control signals to the big engines for compensation. Finally, the subsystem computes and initiates stage cut-off at the appropriate time in flight.

Analog inputs from the sensors are accepted by the data adapter and digitized for computer use. Computer outputs are converted back to analog form by the DA as required.

Once in orbit, the computer is employed for propulsion-system checkout and to test and checkout the mid-course guidance and control system and other supporting or related instrument unit subsystems. Results of those checks are directed to ground for evaluation prior



COMPUTER EMPLOYS 150 "page" assemblies (right) containing up to 35 highly miniaturized electronic Unit Logic Devices.

to initiation (by ground control) of the lunar-trajectory injection mode.

The computer again performs its navigational and steering role for injection. It completes its flight operating function with booster cut-off and separation directions.

● **Improvements manifold**—In comparing the new *Saturn V* guidance computer and data adapter with its predecessor in the *Saturn I* guidance system (also developed by IBM), the differences and improvements are striking.

While the *Saturn I* computer was an adaptation from the system used in the Air Force *Titan II* ICBM, the new equipment was designed to meet more rigid weight and reliability needs. The operating span, operating environment and versatile performance of the *Saturn V* guidance system demanded a vastly more sophisticated computer with greatly increased capacity and capability for future expansion without the need for redesign. (See the accompanying table of equipment.)

With only a slight weight and volume increase, the *Saturn V* computer/data adapter provides three times the operating speed, a 6000% mean-time-between-failure reliability increase and four times the storage capacity of the *Saturn I* computer. Further, it employs nearly seven times the number of electronic components and requires 100 watts less total power.

The present 460,000-bit storage capacity can be readily doubled by merely plugging in the necessary memory modules.

● **Computer details**—To meet the tight weight and size limitations and still obtain the necessary high capacity and reliability needs for the guidance computer, IBM's design included triple modular redundancy, a new line of unit logic devices, duplex memory organization and a liquid-cooled magnesium-lithium chassis. Weighing only 77 lbs., the computer occupies about 2.2 cu. ft. and requires 131 watts total power.

The system is a general purpose, serial, binary data processor. To reduce processing time, addition and subtraction are performed simultaneously with multiplication and division. (Typical processing times: addition—82 μsec.; multiplication 328 μsec.)

A 2.048-mc. crystal oscillator provides primary timing from which four 512-kc clock pulses per bit are drawn. The latter permits inverter loads to be time-shared, eliminating need for an AND diode for each clocked AND.

Four plug-in modules provide a 460,000-bit storage capacity for the random-access magnetic-core memory. Room is available, when needed, to add four more storage modules.

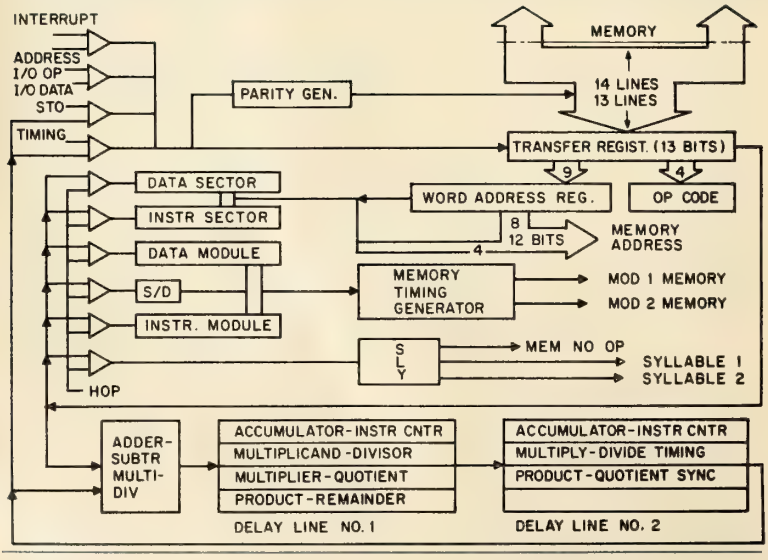
The computer memory can be operated as a single storage device or as two memory units functioning in a parallel or duplex mode. Only the output of a single module, however, is used at any given time. Automatic switching occurs in the event of failure of one memory module and subsequently the out-of-use memory is corrected by the buffer register of the storage unit in use. With this approach, said IBM, the chance of simultaneous failure of both modules approaches zero.

The use of magnesium-lithium-alloy/methanol-water cold plates in the computer and data adapter permitted a 65-lb. weight reduction in chassis design. Believed to be the first successful use of the alloy in electronics structural fabrication, the cold plates provide a temperature reduction of 18°F. (The tendency of the alloy to excessively oxidize and corrode apparently has been eliminated by IBM developed annodizing and coating process.)

● **Redundant design**—In determining the extent of redundancy required to meet reliability needs, IBM identified seven computer functional sections wherein catastrophic failure might occur but could not be permitted to occur.

Each functional section was placed in three identical but independent logic channels. Problems are presented to each module for simultaneous action and the independently derived results go to a majority-rule voter circuit. ■

BLOCK DIAGRAM of Saturn V digital guidance computer indicates data flow.



How big craftsmanship brings big dreams to life . . .

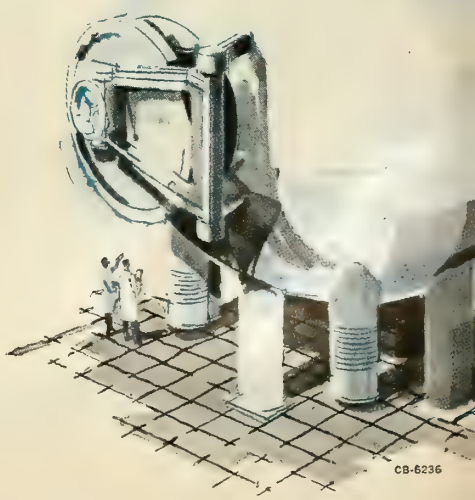
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ITT Affiliate Working on Gas Laser for Guidance System Use

Company financed helium-neon unit could find application in France's Diamant, ELDO booster; rangefinder being tested

PARIS—A gas laser aimed at application in the command guidance systems of the *Diamant* and/or ELDO space boosters is being developed in a company-financed project which is certain to command considerable attention.

Laboratoire Central de Télécommunications (LCT), an ITT affiliate working on the helium-neon laser, emphasizes that neither the *Diamant* national program in France nor the European Launcher Development Organization (ELDO) is publicly or officially committed to use of a laser system. But they have been given confidence by the established advantages of the technique and the known official encouragement of applying such advanced technology.



TECHNICIAN sights with prototype of LCT's ruby laser rangefinder now undergoing tests. Rangefinder is first of its kind developed in Europe, and will be used in tracking role during launch phase of ELDO booster.

The new project follows on the heels of LCT's ruby laser rangefinder, the first in Europe, which is now undergoing intensive field tests. The gas laser, not yet at the hardware stage, will have an accuracy estimated at ±1 meter over ranges up to 50 kilometers. It would be used in a tracking role during launch to feed range and bearing information to command guidance computers.

The gas laser project is somewhat similar to the Perkin-Elmer development in the United States, although LCT officials feel that the P-E performance figures are rather optimistic and do not take into account certain deteriorating factors.

Among these are atmospheric backscatter, which LCT views very seriously, and other phenomena which will affect the accuracy of such systems. The LCT design differs from the P-E unit in the modulation technique and other respects.

Henri Bosc, of LCT's laser application department, said the company's helium-neon laser will use d-c excitation, and preliminary work has been carried out for some time with an 8-meter laboratory laser. The lab setup has been used for theoretical study of laser lines in helium, neon, argon, xenon and krypton. About 20 new lines have been discovered, and there is evidence of a cascade laser. Molecular changes in various gases have also been studied.

The company-financed project may receive contractual support later, like the LCT-funded ruby laser rangefinder, which was supported in-house until con-

tracts were let by the military services.

● **Ruby laser**—LCT's ruby laser rangefinder, was demonstrated for MISSILES AND ROCKETS on a Paris rooftop. On a misty rainy day, it individually picked out two church steeples extremely close together at a range of 6,420 meters. The biggest problem consisted of successfully aiming the very narrow beam.

Messrs. Cagniard and Grassot, of LCT, who demonstrated the device, said they successfully picked out 1,500-meter-distant advertising signs where only half the laser beam was intercepted by the target.

The beam bandwidth is one milliradian, which would dictate a tripod mounting for an operational military version, expected to be about half the volume shown in the accompanying photographs. During the demonstration for M/R, the maximum range attained was 8,800 meters through heavy mist.

Nominal range of the unit, which began operating in prototype form in early 1963, is 3.5 km on an average vehicle, but 5 km is not uncommon and LCT says the absolute maximum attained is 12 km on a perfectly clear day against a flat white wall.

Accuracy of the ruby model is ±5 meters at any distance, and divergence of the light pulse is 0.5 milliradian. Delay time between the triggering and the pulse varies; actual passage of the pulse from the unit is measured by a photocell, and the return pulse similarly measured. Tens of nanoseconds accuracy is required in this approach.

Bosc says the most difficult development problem is the stability of filters, whose quality deteriorates with time, temperature and humidity. The narrow filters quickly go out of tolerance.

LCT TECHNICAL DATA ON RUBY LASER RANGEFINDER

TRANSMITTER	
Peak power of transmitted pulse	1 MW
Duration	(Less than) 50 nanoseconds
Leading Edge	(Less than) 15 nanoseconds
Repetition period	3 seconds
Beamwidth (pencil shape)	0.5 milliradian
Wavelength	6,943 Angstroms
RECEIVER	
Optical receiving area	50 cm^2
Angular aperture	1 milliradian
Optical bandwidth	40 Å
Quantum efficiency	0.02 (approximately)
Electrical bandwidth	25 mc
COUNTING CIRCUIT	
Clock frequency	29.970 mc
Range display	0 to 9,995 m, in 5-m steps
RESULTS	
Maximum useful range	3.5 km on average vehicle in clear weather
Precision	±5 m

The transmitter is the Q-switch type, with a pulse on the order of 1 MW and 50 nanoseconds of time. Rise time is 10-20 ns, corresponding to three meters' travel. The prism rotates at a rate of 18,000 rpm.

● **Design details**—Through a telescope aligned with the laser axis, the operator sights the target precisely with the aid of crosshairs. Pressing the trigger button transmits the pulse from the laser head, and a gate is opened to start the counting of regularly spaced pulses supplied by an electronic clock. The gate closes when the receiver detects the light pulse reflected from the target; the counting then ceases.

The counter measures time elapsed between transmission and reception, and is calibrated in range units, thereby enabling direct display of distance in meters and kilometers. This display is instantaneous via a digital readout unit.

Transmitter layout uses a mirror, which is neither silvered nor dielectric, in conjunction with the laser crystal. LCT says this lends sturdiness. On one side, the ruby crystal is cut as a total reflection prism; on the other side the interferometer is completed by a mobile prism rotating at 18,000 rpm. A small percentage of the energy circulating in the interferometer is intercepted by a transparent flat to make up the output beam.

Receiver layout consists of an optical assembly of high luminosity which intercepts exclusively signals coming through a cone of small angular aperture; an optical filter with limited bandwidth centered on the wavelength being used; a photomultiplier with amplifier; and a threshold device designed to admit only those signals exceeding noise by a specific value.

The transmitter-receiver unit is tripod-mounted and oriented by means of a universal swivel joint. Connected with this is the power supply, operating from either a 50c/s main line or from 24v battery of accumulators.

Since there was no effort at miniaturization, the initial model weighed a total of 40 kg, but LCT says a production model would weigh about half this. In addition to the transmitter-receiver unit and power supply, an indicator unit is integrated with the system, containing electronic counting circuits and numerical range indicators in the form of digital readouts. ■

GE's Gemini/Bios Fuel Cell Progresses

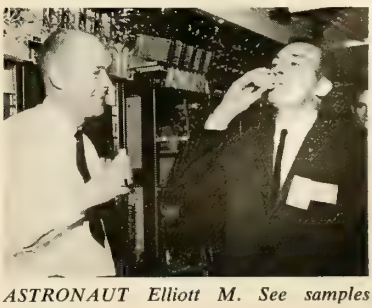
THREE MILESTONES in the development of fuel cell power systems for spacecraft use have been announced by General Electric's Direct Energy Conversion Operation (DECO) in Lynn, Mass.

GE, under contract to supply the oxygen-hydrogen fuel cell system for the *Gemini* spacecraft, reports that a production fuel cell battery has been successfully operated for more than six weeks, about three times the requirement for the manned 14-day *Gemini* mission. GE says the battery maintained a specified output (though they would not specify what it was, other than to say it was below the 2-kw peak power requirement of the two-cell *Gemini* system) for 1,100 hrs.

The battery under test underwent a vibration test simulating *Gemini* launch prior to the 1,100-hour run, and also went through an eight-hour "heavy load cycle" just prior to shut down. This was meant to simulate a high-power demand just before re-entry. Power levels at this operation are also reportedly classified, though GE did tell MISSILES AND ROCKETS the load increased about 300% from the load in the simulated 46-day flight. (M/R, June 8, p. 29).

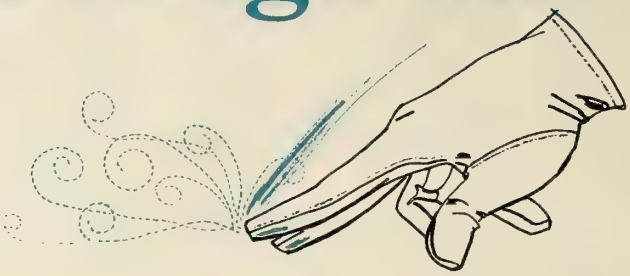
GE also announced successful test of another production battery in a simulated *Gemini-Agena* rendezvous mission. This mission, according to the firm, requires a high output of nearly 1 kw at 43 amps for a short period. The run was started after 100 hours of preflight checks, which included seven stop/start operations and a 1.1 kw peak.

GE also formally announced that DECO will supply the fuel cell system for NASA's *Biosatellite*, being built by GE's Re-Entry Systems Dept. in Philadelphia. The award had been expected (M/R, June 8, p. 29). The *Bios* battery will include 32 individual cells and the complete system for the 30-day mission will weigh 210 lbs. ■



ASTRONAUT Elliott M. See samples some of the water that is a by-product of fuel cell operation. GE is producing batteries for Gemini spacecraft fuel cell.

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Circle No. 5 on Subscriber Service Card

RCA System Pinpoints Satellite Size, Shape, Orbital Characteristics

by Rex Pay

SAN FRANCISCO—Automatic identification of satellites and transmission of their orbital data to the spacetrack center in Colorado Springs, Colo., is being carried out at the Moorestown Space Track Facility, N.J., under control from an RCA 4102-S computer.

Commanded by the Space Track Sensor Computer (SPASEC) real-time program, the computer locates new satellites soon after launching and keeps updated orbital records of all identified satellites. It also indicates individual satellite size, shape and stability. Alterations in a satellite's orbit, such as a plane change, are automatically recorded.

A new addition to the system is the transmission of real-time pointing data (2,400 bits/sec.) from Moorestown to a narrow-beam short-range radar in Baltimore.

Additional storage capacity will be added to the system when the known satellite population becomes much larger than the present 400 objects.

The Moorestown radar in real-time communication with the 4102-S operates in a surveillance mode, to provide data on all orbiting objects passing through the volume scanned, or in a tracking mode, to provide more accurate orbital data on selected objects.

SPASEC was conceived as a single-purpose system, rather than general-purpose, that would operate 24 hours a day, seven days a week. The computer program used was outlined by E. T. Garner and J. Oseas of RCA at the Fall Joint Computer Conference held here last week.

• **Operation**—The computer receives information from the radar in the form of digital signals representing range, azimuth, elevation, Doppler shift and time. From these, it produces smoothed radar observations in the form of time, range, azimuth, elevation and identity of satellite, if known. This information is transmitted over teletype to Colorado Springs.

Orbital elements of all known satellites, with constant updating, is transmitted to Moorestown over the teletype link from the central data and cataloging center, which is in communication with all members of the Spacetrack network. The center also provides Moorestown with a priority list of desired observations.

Missions are planned by taking account of such new information requests, object priority, number of expected sightings and probability of detection. The plan is carried out by the tracking radar control console operator, who directs the radar to scan a selected sector. This is the extent of the manual intervention in normal operation.

As the radar scans its assigned region of space, parameters of detected objects enter the computer store. These data are compared on a scan-to-scan basis to see if they might reasonably be expected to have come from a single object. If they do, they are considered associated and are combined and smoothed to an approximation of target position and velocity.

When the program determines that no more useful scan data can be gained, identification is attempted by comparing the estimated position and velocity with predicted radar fan penetrations by known satellites.

Penetrations that will be relevant are computed in advance for a given radar scan coverage, by reference to an ephemeris file. The penetrations are stored in a time-ordered sequence.

Final target information includes range, range rate, range acceleration, azimuth, azimuth rate, elevation, elevation rate, time and an accuracy index. This is compared with the ephemeris file by a comparator program, yielding one of the following results: fine, passed comparison with close time and position tolerances; coarse, passed comparison within broad time and position tolerances; coarse, tentatively identified with more than one object; uncorrelated, object unidentified.

A computer routine then decides whether operation should switch from the scan mode to the track mode.

Uncorrelated objects pass through discrimination tests to check if the object is a satellite. Based on energy considerations, the tests eliminate meteors, the Moon and noise. Targets, including those passing these tests, are given tracking priorities, depending on identification, data age and the probability of detection.

To automatically track an object, the program directs the radar to point along the object's path slightly ahead of it. The designated point is computed for current time plus half a second and is valid for one second. If the object is not detected, a new designated point is computed. This procedure may continue for 30 seconds. If the object is detected in this period, the radar automatically locks on and tracking starts.

• **Smoothing**—Track data is smoothed using unweighted arithmetic means with least-squares fits to develop the rates. The final tracking information contains range, range rate, azimuth, azimuth rate, elevation, elevation rate, average angular credences and orbital elements consisting of inclination, period, semi-major axis, eccentricity and right ascension. Ten seconds of radar information provide these data.

The 4102-S computer used in the system is the most recent addition to the 4100 series built by RCA, Van Nuys, Calif. It is a 16-level, 30-bit word length, parallel, binary, 2's complement, stored-program computer. It has 16 program counters and 96 full-length index registers. An add instruction requires 19.2 microseconds and multiply, 75.5 microseconds. The machine is paper-tape oriented.

An Analex 41000, capable of printing 1,000 lines per minute, is used to provide hard copy of the penetrations of the surveillance sphere of the radar.

An interface unit enables the computer to communicate in various ways with the teletype link. In the automatic mode, incoming information is made available to the computer directly from the tape punch heads, and outgoing information is transmitted automatically to the spacetrack center, from the punch heads, with a back-up paper tape being produced. ■

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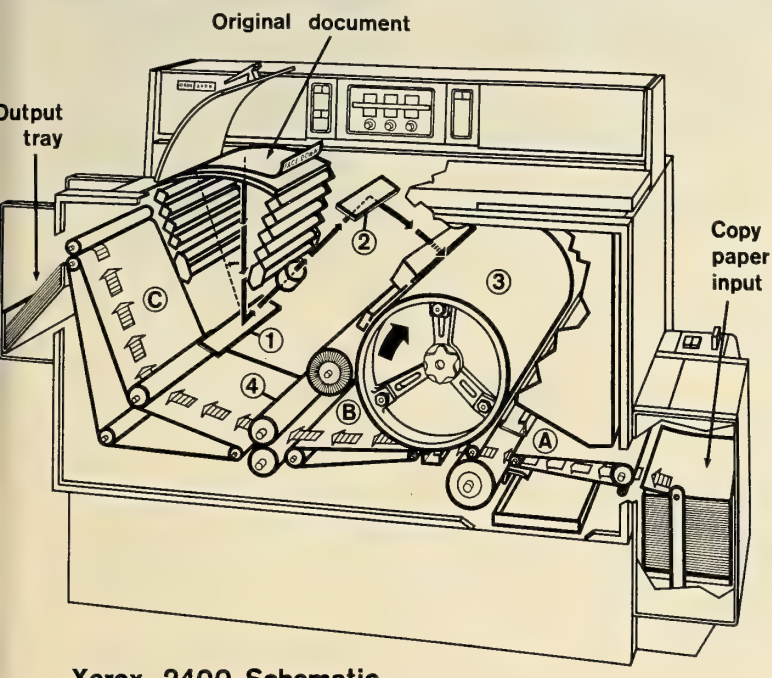
High-Speed Copier

An office system reproduction device capable of making copies directly from an original document at rates up to 2,400 per hour has been developed and demonstrated by Xerox Corp.

The Xerox 2400 is an automatic, continuous-output unit that produces black and white copies from opaque, transparent or translucent originals up to 9x14 in. in size with image areas not exceeding 8.5x13 in. The paper supply tray holds four reams of paper and has an elevator that can handle any of three predetermined sizes.

The increased operating speed of the 2400, Xerox says, is the result of developments in the optical, developing and fuzing systems and an increase in the drum speed. The optical system uses a mirror that oscillates to scan a curved glass platen on which the original document is placed. Each scan takes 1.5 seconds.

The unit has a photoconductive drum guaranteed to 100,000 copies. Power requirements are 208 to 240v, approximately 4,500 va. The device is initially available on a lease basis only.



Xerox 2400 Schematic

1. Oscillating mirror
2. Fixed mirror
3. Selenium coated drum
4. Roll fuser

A, B, & C-Paper transports

Circle No. 151 on Subscriber Service Card

Warning-Signal Generator

Marshall Precision Components, Inc., is marketing a solid-state warning-signal generator that provides any of several warning outputs.

The Model SSW-622-027 monitors a given input to the preselected level. At that point, three warnings are triggered: two audio outputs and one warning-lamp output. Each audio channel has a 1-kc tone that is interrupted with a 50% on-off cycle at a rate of 4 to 6 cps. A third warning is an interrupted 28-v signal with the same cycle and rate that flashes a 28-v, 60-ma lamp.

A potentiometer permits selection of the trigger signal in the range from 10 to 90% input. The unit is internally compensated for a voltage variation of ±15% and compensated so that triggering will occur at the same point ±1% over a −25° to 160°F temperature range.

Circle No. 152 on Subscriber Service Card

Control Amplifier

Power Instruments, Inc., is marketing the "Sensor-Matic," a control amplifier designed to put "touchless" sensors to work. The device has inputs to accept signals from photoelectric or magnetic pickups and on-off conduction from a contactor switch. All inputs are subject to selectable delay from 0.002 to 1.0 second.

Four outputs are provided: 3v peak pulse; high impedance, to operate electronic counters to speeds up to 5 million/minute; 12v peak, low impedance, to fire SCR's to speeds up to 30,000/minute; 50 va reed relay contacts for speeds up to 9,000/minute; and double pole, double throw power relay (optional) for handling loads up to 10 amps to rates to 100/minute.

Circle No. 153 on Subscriber Service Card

Tape Reader

A bi-directional perforated tape reader capable of reading 120 characters per second is being marketed by Tally Corp.

The Model 464 can read data from 5-, 6-, 7-, or 8-level tape. The asynchronous unit has a non-return-to-zero feature made possible by the star wheel reading principle and said to appreciably simplify system logic. Tape may be read accurately in excess of 1,000 passes.

Circle No. 154 on Subscriber Service Card

Set Point Station

An instrument designed to link a computer to analog control equipment used in manufacturing processes has been announced by IBM's Industrial Products Div.

The IBM set point station Model 891 is designed to accept and convert the output of a digital computer to analog signals and transmit these signals to a controller. Two models of the device are available—one with pneumatic process instrumentation and one with electronic process instrumentation.

Either "slew," "trim," or multiple (pulse) contact closures can be accepted from the computer by the device's set point station. A slew pulse of 2.5 secs. produces 20 steps; a trim pulse of 0.5 sec. produces one step. In the pulse mode, maximum stepping rate is 100 steps/sec.

Circle No. 155 on Subscriber Service Card

beyond apollo—
the U.S. space program



4th annual NASA issue

november 30, 1964

MISSILES AND ROCKETS, the weekly of Space Systems Engineering, will publish its fourth annual NASA Issue on November 30, 1964.

This annual issue, now accepted as the authoritative publication on the nation's space agency, will examine future procurement plans of the National Aeronautics and Space Administration and three organizations allied with it in exploring the peaceful uses of space, Communication Satellite Corporation, Atomic Energy Commission and the U.S. Weather Bureau.

With major procurement for the Apollo manned lunar landing program now behind it, NASA is deep in the planning for new projects to expand man's knowledge of space, including such post-Apollo missions as the Lunar Logistic Supply System, Manned Orbital Research Laboratory, Extended Apollo, Project Voyager and Manned and Unmanned Planetary Probes. ComSat Corp., AEC and the Weather Bureau are drawing up plans for their growing participation in the peaceful use of space.

This issue of MISSILES AND ROCKETS provides the recognized and authoritative route to reach the men who will be making the research, design, engineering and procurement decisions in these new multi-billion dollar programs.

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publication date—nov. 30, 1964 **advertising closes—nov. 16, 1964**

missiles and rockets

American Aviation Publications, Inc., 1001 Vermont Ave., N.W., Washington, D.C. 20005

Missile/Space Facilities

The Marquardt Corp. on Oct. 30 dedicated a new remote rocket test facility at Magic Mountain, Calif., 30 miles north of the firm's Van Nuys plant. The test site consists of 640 acres of mountainous land leased from the U.S. Forestry Service and includes facilities for testing complete attitude control reaction rocket clusters and systems Marquardt is developing for the Lunar Excursion Module. Two stands at the new site will be used for testing cryogenic and other high-impulse liquid propellants. . . . *Massachusetts Institute of Technology and AC Spark Plug have completed a laboratory in Downey, Calif., for checking out and servicing Apollo guidance and naviation systems. The lab is on the premises of North American Aviation's Space and Information System Div., where the three Apollo modules are being built and assembled and the subsystems installed. The Downey lab is first in a series of field facilities being established by the team of Apollo G&N developers to afford in-flight G&N systems.* . . . Whittaker Corp.'s Naramco Research and Development Div. has announced plans for construction of a new research facility in Research Park, San Diego, Calif. The new building will add 23,353 sq. ft. to existing Narmco research facilities and is expected to be ready for occupancy in February, 1965. Narmco is active in the fields of structures, components, devices and subsystems in the technical areas of plastic and ceramic radomes, expandable structures for satellite components, and sea water conversion.

Mergers and Acquisitions

Crescent Engineering & Research Co., Glenside, Pa., and El Monte, Calif., has acquired substantially all the assets and operations of Semiconductor Magnetics, Inc., a wholly owned subsidiary of National Astro Laboratories, Inc. of Pasadena, Calif. Crescent has been a supplier of transducers, signal conditioning equipment, proximity detectors, electromyographs, tonometers and chronaximeter stimulators for the military, aerospace, industrial and medical markets. With the SMI acquisition, Crescent will add to its products current regulators, voltage regulators, dc-dc converters, amplifiers, dc power supplies and voltage controlled oscillators. . . . *The Society for Nondestructive Testing has absorbed the Infrared Techniques for Electronics Committee. The merger will provide SNT's Technical Council the capabilities necessary to delve into applications of infrared techniques to a wider scope of industrial activities. The function of ITEC has been to disseminate information concerning application of infrared techniques to electronics equipment evaluation and testing.* . . . The Benrus Watch Co., Inc., New York City, has purchased the assets of Rapromatic, Inc., Syosset, N.Y., manufacturers of rapid film developing equipment for use in instrument recording. Purchase is said to be in line with Benrus expansion aims in the field of electronic instrumentation. . . . *Federal-Mogul-Bower Bearings, Inc., of Detroit has agreed to acquire Haller Incorporated Northville, Mich., a producer of powder metal parts. Move is intended as an important diversification in the F-M-B product line.* . . . The Sunbeam Corp., Chicago, has acquired Planet Instrument, Inc., Ft. Wayne, Ind., which will be operated as a separate manufacturing subsidiary of Sunbeam Electronics, Ft. Lauderdale, Fla. Planet Instrument manufactures miniature precision mechanisms such as speed reducers, servo assemblies and ultra-precision gearheads. Sunbeam Electronics' president C. I. Rice said there are no plans to move Planet from Ft. Wayne. He added that Planet's products will be handled by the component division of Sunbeam. . . . *Military & Computer Electronics Corp., Ft. Lauderdale, Fla., has converted a $300,000 debenture against the company to unissued stock. Irving J. Johnson, president of the electronics firm, said the transfer will permit the company to accelerate expansion needed to design and manufacture several product lines for commercial and industrial markets. Until recently, the firm has been principally engaged in designing, developing and manufacturing a line of high reliability, miniaturized electromagnetic components for the defense and aerospace fields.*

Standardized Computer Language Urged

RCA chairman David Sarnoff told an audience at the Fall Joint Computer Conference in San Francisco last week that the American computer industry is functioning in a "technical Tower of Babel" that threatens its future growth. He said needless duplication, delay and waste has resulted from the absence of a commonly understood and accepted language between both computers and their operators. Sarnoff cited the existence of what he termed a conservative count of more than 1,000 programming languages, many with numerous dialects. Whether the computer industry realizes its full growth potential, he said "depends in very large degree on the measures we undertake now to establish the basis for orderly development."

New Activities

Beech Aircraft Corp. has conferred full division status on its missile engineering program. The new Missile Systems Div. will perform R&D and production work on such programs as *AADS-70* and the *AQM-37A* target missile. . . . *Beckman Instruments, Inc., has formed a new unit, the Physiological Measurements Group, to develop new physiological instruments and systems for hospitals, clinics and biological research.* . . . Raytheon Co. has formed a new Components Div., composed of the company's former Industrial Components, Machlett Laboratories, and Semiconductor divisions. Facilities involved in the consolidation are the Industrial Components plants at Newton and Quincy, Mass.; Machlett Laboratories' plants at Springdale and Stamford, Conn.; Penta Laboratories' plant at Santa Barbara, Calif.; and the Semiconductor operations at Mountain View, Calif.

contracts and procurements

AWARDS

AIR FORCE

$34,500,000—**General Telephone and Electronics Corp.,** Sylvania Electric Products (subsidiary), New York City, to produce a command and control system for 150 *Minuteman* missiles and 15 underground launch centers in eastern North Dakota.

$2,668,819—**North American Aviation, Inc.,** Anaheim, Calif., for repair of *Hound Dog* air-to-ground missiles.

$1,000,000—**North American Aviation, Inc.,** Canoga Park, Calif., for continued production of *Atlas* rocket engines.

$1,000,000—**Avco Corp.,** Everett, Mass., for radiation research.

$347,000—**Cook Electric Co.,** Tech-Center Div., Morton Grove, Ill., for the production of electrical drive systems designed and developed for radar installations.

$268,000—**Fairchild Hiller Corp.,** Data Systems Engineering Group, Washington, D.C., for delivery of two MOBILAB vehicles. MOBILAB is a self-propelled rapid photo processing laboratory designed to process aerial reconnaissance film.

$252,250—**General Electric Co.,** Heavy Military Electronics Dept., Syracuse, N.Y., for classified test for BMEWS.

$241,246—**Itek Corp.,** Lexington, Mass., for the production of 12 small, lightweight aerial camera systems and associated equipment.

$117,150—**North American Aviation, Inc.,** Space and Information Systems Div., Downey, Calif., for research on stability and transition of laminar boundary layer.

$114,920—**Princeton University,** Princeton, N.J., for research on propellant rocket motor combustion processes.

$54,865—**TRW/Space Technology Labs,** Redondo Beach, Calif., for exploratory development program to demonstrate the feasibility of utilizing the energy of decay of an alpha emitting radio-isotope as a heat source in a direct cycle space thrustor which utilizes hydrogen as a propellant.

$36,452—**Northeastern University,** Boston, for mechanical design and payload integration of two sounding rockets.

$34,882—**Hughes Aircraft Co.,** Hughes Research Labs Div., Malibu, Calif., to investigate dispersion effects in laser amplifier.

International Telephone and Telegraph Corp., Kellogg Communications Systems (subsidiary), Chicago, to provide continued maintenance and operation services for space communications at Vandenberg AFB, Calif. (amount undisclosed).

Cornell Aeronautical Laboratory, Buffalo, N.Y., to study the feasibility of applying radar correlation interferometer techniques to satellite observation for project TERF, an Advanced Research Projects Agency undertaking.

Ralph M. Parsons Co., Los Angeles, to provide the architect-engineering services necessary to develop engineering specifications and final design of another squadron of *Minuteman* ICBM's and their site.

ARMY

$5,600,000—**Philco Corp.,** Aeronutronic Div., Santa Ana, Calif., for work on *Shillelagh* missile system.

$3,900,000—**General Dynamics Corp.,** Pomona, Calif., for engineering services in connection with *Redeye* anti-aircraft missile system.

$1,400,000—**General Dynamics Corp.,** Pomona, Calif., for continued work on *Redeye* missile.

$950,000—**Western Electric Co., Inc.,** New York City, for engineering design, modification and servicing missile ground guidance equipment.

$75,000—**Thiokol Chemical Corp.,** Redstone Div., Huntsville, Ala., for engineering design and manufacture of components in support of liquid propellant R&D program.

$65,958—**Raytheon Co.,** Lexington, Mass., to study ways to predict new infrared laser materials suitable for night viewing use.

$35,192—**Cornell Aeronautical Lab., Inc.,** Buffalo, N.Y., for transonic wind tunnel tests in support of *MAW-Zuni* project.

$25,455—**Emerson Electric Co.,** St. Louis, for telemetry system components for incorporating in rocket vehicle system under development.

$24,683—**Geophysics Corp. of America,** Bedford, Mass., for three-month study to analyze the use of infrared scanning sensors applicable to *Nike-X* missile system.

Lear Siegler, Inc., Astronics Div., Santa Monica, Calif., to provide five engineering development models of a yaw damper and heading control system for the UH-1B Iroquois helicopter. The system was developed to increase the helicopter's directional stability while aiming, firing and guiding various weapon systems, including air-to-surface missiles (amount undisclosed).

NAVY

$3,087,236—**Lockheed Aircraft Co.,** Sunnyvale, Calif., to repair *Polaris* missile equipment.

$2,072,000—**Fairchild Camera and Instrument Corp.,** Du Mont Laboratories Div., Clifton, N.J., for the production of television equipment to operate in conjunction with the *Terrier* missile system.

$1,700,000—**International Telephone and Telegraph Corp.,** Data and Information Systems Div., Paramus, N.J., to provide computer programming services to the Fleet Computer Programming Center in Dam Neck, Va.

$617,199—**Chromcraft Corp.,** St. Louis, for rocket launchers.

$332,291—**General Electric Co.,** Washington D.C., for manufacture of guidance test equipment for United Kingdom.

$253,255—**Booz, Allen and Hamilton, Inc.,** Chicago, for technical management study to determine in-house capability, capacity and utilization of Navy organization in support of *Polaris* weapons system.

$245,156—**General Electric Co.,** New York City, for *Polaris* fire-control and guidance-systems trainers.

$149,345—**U.S. Rubber Co.,** Research Center, Wayne Township, N.J., to extend period of contract for R&D of improved insulators for rocket motors.

$145,300—**National Engineering and Science Co.,** Pasadena, Calif., for R&D study of characteristics and applications of novel configuration re-entry bodies.

$144,873—**Edwin A. Keeble Associates, Inc.,** Nashville, Tenn., for research and services, preparation of logistics information in support of maintenance and production of surface missile system.

$103,000—**Westinghouse Electric Corp.,** Aerospace Div., Baltimore, for engineering services to support training installations, checkout, interface resolution, trouble-shooting and maintenance for *Polaris* equipment.

$71,974—**Georgia Institute of Technology,** Georgia Tech Research Institute, Atlanta, to extend contract for R&D on ceramic systems for use as structural components in hypersonic missile applications.

$50,535—**Aerojet-General Corp.,** Sacramento, Calif., for facilities in support of the contractor's performance in the fleet ballistic missile program.

NASA

$2,606,448—**Hayes International Corp.,** Birmingham, Ala., for electro-mechanical distribution panels.

$2,500,000—**Dynamics Corp. of America,** Reeves Instrument Div., Garden City, N.Y., to build three radar tracking antenna systems for the *Apollo* program.

$1,000,000—**C-E-I-R Inc.,** Arlington, Va., for computer programming and related services over a three-year period.

$345,000—**Cornell Aeronautical Laboratory, Inc.,** Buffalo, N.Y., for a study of *Apollo* re-entry conditions, particularly as they affect communication blackout.

$125,719—**Serendipity Associates,** Sherman Oaks, Calif., for study of crew functions and vehicle habitability requirements for long-duration manned space flights.

$43,000—**Lockheed Missiles and Space Co.,** Palo Alto, Calif., for study of spacecraft on-board test and data-processing techniques.

Ionac Chemical Co., Birmingham, N.J., to develop a pocket-size emergency kit for spacemen that will convert sea water into palatable drinking water.

Battelle Memorial Institute, Columbus, Ohio, for a study of several different types of microelectronic circuits available from industry under conditions similar to those in the Van Allen radiation belt (amount undisclosed).

NATIONAL SCIENCE FOUNDATION

$83,000—**Rice University,** Houston, for a three-year study of the energy in thunder and its possible effect on the ionsphere.

INDUSTRY

$4,000,000—**Honeywell, Inc.,** St. Petersburg, Fla., from **North American Aviation, Inc.,** Canoga Park, Calif., accelerometers for *Minuteman II* missile guidance system.

$2,400,000—**Sperry Rand Corp.,** Sperry Gyroscope Co., Great Neck, N.Y., from **The Boeing Co.,** Seattle, to design and produce the inertial reference unit for the camera-carrying *Lunar Orbiter* spacecraft.

$1,937,200—**Chicago Bridge & Iron Co.,** Atlanta, from **Catalytic Construction Co.,** Philadelphia, for design, fabrication, installation, cleaning, and testing of cryogenics storage spheres to be used in support of the *Apollo/Saturn V* launch vehicle.

$1,655,700—**Union Carbide Corp.,** Linde Div., Indianapolis, from **Catalytic Construction Co.,** Philadelphia, for the design, fabrication, installation, cleaning and testing of all vacuum-jacketed piping necessary to transfer the liquid propellant from storage facilities to the *Apollo/Saturn V* launch vehicle.

$1,150,000—**Kaminer Construction Co.,** Chamblee, Ga., from **Catalytic Construction Co.,** Philadelphia, for cross country gaseous piping system; pumps, vaporizers, compressors and desiccant racks in the converter compressor facility with associated piping; and the installation of 124 6,000-to-10,000 psig gaseous storage vessels to be used in storage vessels to be used in support of the *Apollo/Saturn V* launch vehicle.

$1,000,000—**Watkins-Johnson Co.,** Palo Alto, Calif., from **ITT Federal Laboratories,** Nutley, N.J., for development and delivery of advanced design broadband receiver systems.

$675,000—**Precision Instrument Co.,** Palo Alto, Calif., from **Aerojet-General Corp.,** AETRON Div., El Monte, Calif., for instrumentation magnetic tape recorders for installation at NASA's Mississippi Test Operation.

International Telephone and Telegraph Corp., Federal Laboratories, Astrionics Center, San Fernando, Calif., from **Collins Radio Co.,** Dallas, to develop special receivers for the *Apollo* Unified S-Band Tracking System that will link Earth to space vehicle (amount undisclosed).

REQUESTS FOR BIDS

GENERAL PROCUREMENTS

Purchasing Office
George C. Marshall Space Flight Center
National Aeronautics and Space Administration
Huntsville, Ala. 35812

A study of structural response to inflight acoustic environment. RFP issued 10/23/64, due date is 30 days from issuance. RFQ 1-5-53-01081-01.

Directorate of R&D Procurement
System Engineering Group
Research and Technology Division
Wright-Patterson AFB, Ohio 45433

Negotiations will be conducted with Thiokol Chemical Corp., Denville, N.J., for research on elastomeric and complaint materials resistant to liquid rocket fuels and oxidizers.

NASA Manned Spacecraft Center
General Research Procurement Branch
2101 Webster-Seabrook Road
Houston, Texas 77058
Attn: Hilda Bolling

Negotiations will be conducted with Dynatech Corp., Cambridge, Mass., for the development of a general method for the calculation of radiant interchange between spacular-diffuse surfaces. For information only, RFP not available.

Procurement Division
Bldg. 4603
Aberdeen Proving Ground, Maryland

R&D program entitled "Research on Combustion of Solid Propellants". RFQ-RD-APG-66-65: RFQ due date is Dec. 15, 1964. Requests will be honored on a first-come, first-served basis and will not be honored after Dec. 1, 1964.

George C. Marshall Space Flight Center
Huntsville, Alabama 35812

Study for improvement of instrumentation for analysis of particle contamination in liquid and air streams; negotiations will be conducted with ITT Research Institute, Chicago, for continuation of their contract. For information only, RFP not available.

Directorate of R&D Procurement
Systems Engineering Group (RTD)
Wright-Patterson AFB, Ohio 45433
Attn: SEKNA—RFP No. 18140-KNA

Research and development for an investigation of the effects of ablation product characteristics and thermal lags on re-entry vehicle dynamic stability. Request for RFP must be received by Nov. 10.

Directorate of R&D Procurement
Systems Engineering Group
Research and Technology Division
Wright-Patterson AFB, Ohio 45433

Negotiations will be conducted with Control Data Corp., Minneapolis, for a research program for operational testing of the star occultation technique aboard a *Gemini* vehicle. For information only, RFP not available.

Purchasing Officer
George C. Marshall Space Flight Center
Huntsville, Ala., 35812
Attn: R. A. Parsley

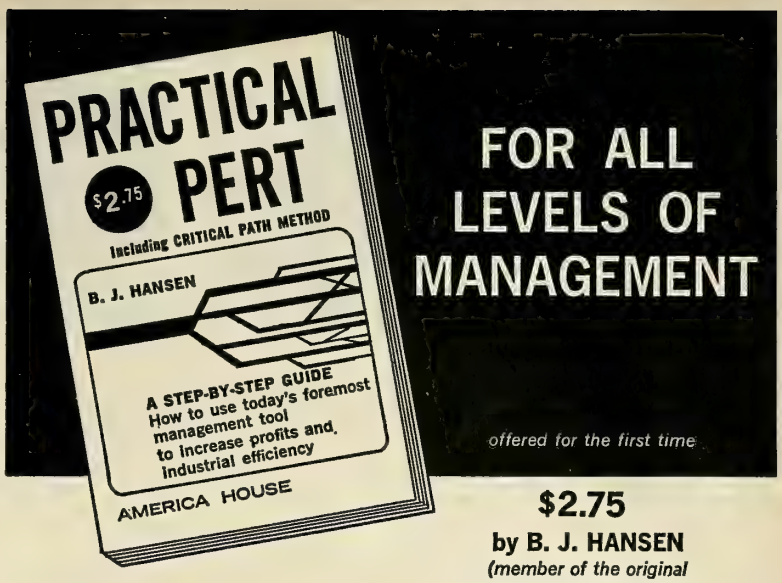
Negotiations will be conducted with Lockheed Aircraft Corp. for a study of modular nuclear vehicle design concepts, associated technological problems and nuclear safety systems. For information only, RFP not available.

Aerospace Space Systems Div.
Air Force Unit Post Office
Los Angeles 45, Calif.

Contract for research to perform a satellite protection system study to be negotiated with Radio Corp. of America, Moorestown, N.J. For information only, RFP not available.

Bureau of Naval Weapons
Washington, D.C.

The Bureau of Naval Weapons intends to solicit proposals from the following: (1) Sperry Rand Corp., Sperry Gyroscope Co., Great Neck, N.Y. and (2) Honeywell, Inc., St. Petersburg, Fla. for MK 1 MOD 0 pendulous integrating pendulum for *Polaris* guidance systems. This notice is made solely to inform potential subcontractors of the proposed procurement. It is suggested that small business firms or others interested in subcontracting opportunities in connection with the described procurement, make direct contact with the firms listed.



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(member of the original Polaris-PERT Team)

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IV HOW PERT PLANS
V HOW PERT CONTROLS
VI BUILDING PERT
VII WHAT IS NETWORKING
VIII REFINING THE NETWORK
IX MEASURING MANAGEMENT RISK
X PERT & COST
XI PERT COSTS & COMPUTERS
XII PROFIT PERT & INCENTIVES
XIII PERT DATA DISPLAY

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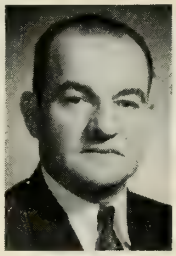
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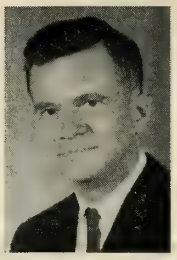
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names in the news


STOBO


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SCHLITT

John G. Stobo: To head the new components division of Raytheon Company, in Newton and Quincy, Mass.; Springdale and Stamford, Conn.; Santa Barbara and Mountain View, Calif. Other new officers are **Robert L. McCormack,** vice president and assistant general manager for Industrial Components; **Joseph W. Skehan,** assistant general manager for Machlett Laboratories; and **Clyde R. Rockwood,** assistant general manager for Semiconductor Div.

Richard G. Bauman: Named director, product development, at The B. F. Goodrich Company's Research Center, Brecksville, Ohio.

J. G. Adiletta: Named President of Pallflex Products Corp., Putnam, Conn., a subsidiary of Pall Corp.

Theodore B. Taylor: Appointed deputy director, scientific, of the Defense Atomic Support Agency (DASA). He was formerly with General Dynamics Corp. He will be principal assistant to the director in the field of nuclear weapons effects research and tests.

L. I. "Russ" Medlock: Named reliability control manager for the **Centaur** space vehicle at General Dynamics/Astronautics, San Diego, Calif. He was formerly quality control specialist for experimental aircraft.

William R. Mandaro: Appointed manufacturing manager for the nuclear fuel section of the SYLCOR Division of Sylvania Electric Products, Inc., New York City.

William Gingras: Named director of engineering for Documentation Inc., Bethesda, Md. He will be responsible for establishment, design and development of hardware products and the automation of documentation production technique.

E. Lloyd Jones: Appointed assistant sales manager for Eldon Fiberglass Manufacturing Co., Compton, Calif.

John J. Pawlak: Appointed technical service engineer at Barrett Chemical Products Div., Allied Research Products, Inc., Chicago. He will provide assistance in special applications.

Edward W. Petrillo: Named manager of RCA Missile Test Project's newly formed "signature operations." In this capacity, Petrillo will be responsible for all RCA activities associated with ships reentry measurement programs conducted on the Eastern Test Range.

Dause L. Bibby: Named president of Stromberg-Carlson division of General Dynamics Corp., New York City. He was formerly a vice president of Sperry Rand Corp.

Omer J. Ruiz: Named contracts manager of the Washington, D.C., office of Aerojet-General Corp. He will represent the company in various negotiations with government agencies.

Helmut W. E. Schlitt: Appointed vice president of new product technology for the guidance and control systems division of Litton Industries, Santa Monica, Calif. He will be responsible for program planning and direction of the division's marine systems group and space sciences laboratory.

Erle M. Constable: Advanced to the presidency of Lockheed Aircraft International, Inc., Los Angeles. He was formerly vice president of a Lockheed subsidiary.

William B. Rieke: Appointed deputy associate administrator of the National Aeronautics & Space Administration, Washington, D.C. He was formerly president of Lockheed Aircraft International, Inc.

William F. Brandt: Appointed contract administrator at ITT Federal Laboratories, San Fernando, Calif. He will be responsible for all contractual administration activities, proposal coordination and presentation, and program control at the laboratories.

Ernest E. Sechler: Elected to the board of H. I. Thompson Fiber Glass Co., Gardena, Calif. He is professor of aeronautics at California Institute of Technology and member and past chairman of the research advisory committee for missile and spacecraft structures at NASA.

Robert S. Bradford: Promoted to technical director of 3M Company's Mincom Division, Camarillo, Calif.

Donald D. Scarff: Elected a vice president of the General Electric Co., New York City. He is also general manager of GE's lamp division.

—when and where

NOVEMBER

1964 Northeast Electronics Research and Engineering Meeting, Somerset Hotel, Boston, Nov. 4-6.

19th Annual Meeting of the Armed Forces Chemical Association, Mayflower Hotel, Washington, D.C., Nov. 4-6.

Joint Meeting of the U.S. Army Materiel Command and the Institute of Environmental Sciences, Aberdeen Proving Ground, Md., Nov. 5-6.

Modern Theories of Adhesion and Their Applications, sponsored by the American Chemical Society and the University of Southern California, Olin Hall Auditorium, USC, Los Angeles, Nov. 6.

Reinforced Plastics—Principles & Applications, a short course at the University of California at Los Angeles, Nov. 9-20.

Symposium on Optical and Electro-Optical Information Processing Technology, sponsored by ONR, IEEE—Professional Technical Group on Electronic Computers, Optical Society of America, and The Greater Boston Chapter of the Association for Computing Machinery, Somerset Hotel, Boston, Nov. 9-10.

Instrumentation in Hazardous Areas, a course sponsored by the Instrument Society of America, Du Pont Country Club, Wilmington, Del., Nov. 11-13.

Management Guide to Numerical Control, a seminar sponsored by the Numerical Control Society, The Summit Hotel, New York City, Nov. 12-13.

Third International Symposium on Bioastronautics and the Exploration of Space, sponsored by the Aerospace Medical Div., Air Force Systems Command, Brooks AFB, Tex., Nov. 16-18.

Conference on Ground Testing in Simulated Space Environment, sponsored by the AIAA, Huntington-Sheraton Hotel Pasadena, Calif., Nov. 16-18.

Annual Meeting of the Association of the U.S. Army, Sheraton Park Hotel, Washington, D.C., Nov. 16-18.

Tenth Conference on Magnetism and Magnetic Materials, sponsored by the IEEE and the American Institute of Physics, Minneapolis, Minn., Nov. 16-19.

Symposium on Microelectronics and Large Systems, sponsored by the Office of Naval Research and the Univac Div. of Sperry Rand Corp., Dept. of Interior Auditorium, Washington, D.C., Nov. 17-18.

Meeting of the Aerospace Research Applications Center, Indiana Memorial Union Building, Indiana University, Bloomington, Nov. 17-18.

Tenth Anniversary Tri-Service Conference on Electromagnetic Compatibility, sponsored by IIT Research Institute, Museum of Science and Industry, Chicago, Nov. 17-19.

Seventh Hypervelocity Impact Symposium, sponsored by the Army, Navy, and Air Force (Secret Clearance and need-to-know certification required for attendance), Tampa, Fla., Nov. 17-19.

Manned Orbital Laboratory Progress Report, sponsored by the American Astronautical Society, Kresge Auditorium, Massachusetts Institute of Technology, Cambridge, Nov. 18-19.

Northeastern States Navy Research and Development Clinic, sponsored by The Franklin Institute, Philco Corp., Temple University, the University of Pennsylvania, the Office of Naval Material, and the National Security Industrial Association, and others, Philadelphia, Nov. 18-20.

Sixteenth Annual MAECON Technical Meeting, Continental Hotel, Kansas City, Mo., Nov. 23-24.

Winter Annual Meeting of the American Society of Mechanical Engineers, Statler Hilton Hotel, New York City, Nov. 29-Dec. 4.

Seventh Annual Army Aviation Contract Services Symposium, sponsored by the National Aerospace Services Assoc., International Inn, Washington, D.C., Nov. 30.

Instrument Society of America One-Week Short Course on Gas Chromatography, Carnegie Institute of Technology, Pittsburgh, Nov. 30-Dec. 4.

Joint Meeting of the American Nuclear Society and Atom Fair, Hilton and St. Francis Hotels, San Francisco, Nov. 30-Dec. 3.

DECEMBER

"A Look Into the Future for Engineers and Management," a conference sponsored by the National Society of Professional Engineers and the Michigan Society of Professional Engineers, Statler Hilton Hotel, Detroit, Nov. 4-5.

57th Annual Meeting of the American Institute of Chemical Engineers, Statler Hilton Hotel, Boston, Dec. 6-10.

Third Conference on Performance of High Temperature Systems, Huntington-Sheraton Hotel, Pasadena, Calif., Dec. 7-9.

Third Annual Western Contamination Control Congress, sponsored by the Western Regional Chapter of the American Association for Contamination Control, Lafayette Hotel, Long Beach, Calif., Dec. 9-11.

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Et Tu, Brute

THE STORM over Secretary of Defense McNamara's new standard of conduct code—now known as the "no-free-lunch" directive—continues. Nothing that has been said in its defense by Mr. McNamara or his associates has softened the insulting tone of the document.

The Secretary, in fact, has put forward an interesting new fiscal doctrine in attempting to find ground on which to defend the amended directive. He told a press conference that company entertainment expenses, even though they come out of profits, ultimately are passed on to the taxpayer in the form of business expense deductions.

This staggering rejection of a company's right to spend its own funds as it sees fit sheds interesting light on Mr. McNamara's view of the defense industry as his own captive production organization which he can treat as he pleases. But as a defense of the new conduct directive, it adds nothing but a further absurdity.

Mr. McNamara apparently believes he can determine proper business deductions for the defense industry far better than can the Internal Revenue Service, in which this responsibility was presumed to lie. Any defense of the new DOD directive on moral grounds is weak enough. To attempt to further support it as a device intended to save the taxpayer money reduces the whole thing to a degrading level.

The Dept. of Defense, which apparently sees nothing morally debatable in telling the press one thing one week and something else the next week, also has reversed itself to reveal that there have been actual instances of questionable conduct which led to the change.

Earlier, you will recall, Mr. Norman Paul, Assistant Secretary of Defense for Manpower, in announcing the new code flatly stated that the amendment was not due to misconduct on the part of either DOD or industry personnel. The change, he said, had been under study for months and there was "no specific instance which brought this thing about."

Now, with the directive under fire, Deputy Defense Secretary Cyrus Vance tells us that, in fact, several cases of alleged irregularities have been under investigation.

We do not intend to comment here on the ethics of DOD's various efforts to justify its decision —either by citing it as a saving to taxpayers or by bringing to light offenses which it previously said did not exist. But we do wish to point out, as has Air Force Association President Jess Larson, the lack of wisdom in tarring the entire defense establishment and its industrial partner with a brush meant for a guilty few.

Yet, Mr. McNamara has found it necessary to publicly insult the defense industry and the members of his own establishment in a directive drawing considerable attention in the foreign press as well as at home.

The decision is questionable in its wisdom and vicious in its implication.

The absurd length to which the situation has been forced is apparent in the plans of the American Ordnance Association for its December dinner in New York, at which Chief of Naval Operations Adm. David D. McDonald will be guest speaker. Since the no-free-lunch code specifically exempts trade associations, AOA has openly asked industry members to submit names of government guests they would like invited. To meet the added expense, AOA has raised the price of dinner seats from $25 to $40. Last year, if a company purchased a table for 10 with seats for six of its own people and four Pentagon guests, the cost was $250. This year, the company will pay $240 for the same table of six company people and four non-paying AOA Pentagon guests.

Despite the $10 per table saving which Mr. McNamara may want to claim for the taxpayer, this at best smacks of gamesmanship—how to win without actually cheating. AOA, which along with AFA has protested directly to the Defense Secretary about the new directive, can hardly be blamed for an attempt to find a way around its absurd intent. But if Mr. McNamara has the strength of his convictions, he will denounce this device and ban the attendance of Pentagon guests. Since their names were submitted by industry firms, it follows that under the standards of the directive, they must be regarded in the first rank of suspects. Mr. McNamara could, of course, take the other tack and insist that all those to attend pay for their own dinners—but that might be a little hard to explain to the taxpayers in the event they all submitted $40 expense items. To say nothing of AOA's confusion in trying to explain a $40 dinner when its guests were paying their own way. The further one goes into the situation, the more ridiculous the regulation becomes.

BUT WE MUST SAY we admire the action of Army Secretary Stephen Ailes in making the code effective immediately—without waiting for the Nov. 24 deadline set by DOD. This delay obviously was built in to benefit the Association of the United States Army, which was well along with plans for its Nov. 16-18 convention. The courage of Mr. Ailes in rejecting this seedy effort to soften the blow contrasts brightly with the strange morality of Mr. McNamara in setting a deadline at which corruption must cease. Presumably, anyone who wants to buy a DOD official with a tieclasp or a lunch is free to do it until Nov. 24. (Thanksgiving turkeys gratefully accepted, but must be postmarked prior to midnight Nov. 23.)

The nauseating idea that ethical standards of conduct can be given a deadline is an unsavory but not surprising one to discover in the philosophy that has led to this unwholesome mess.

There is no quarrel with Mr. McNamara's press conference contention that DOD employees must be "as pure as Caesar's wife." But then she didn't have Mr. McNamara to spread stories about her.

William J. Coughlin

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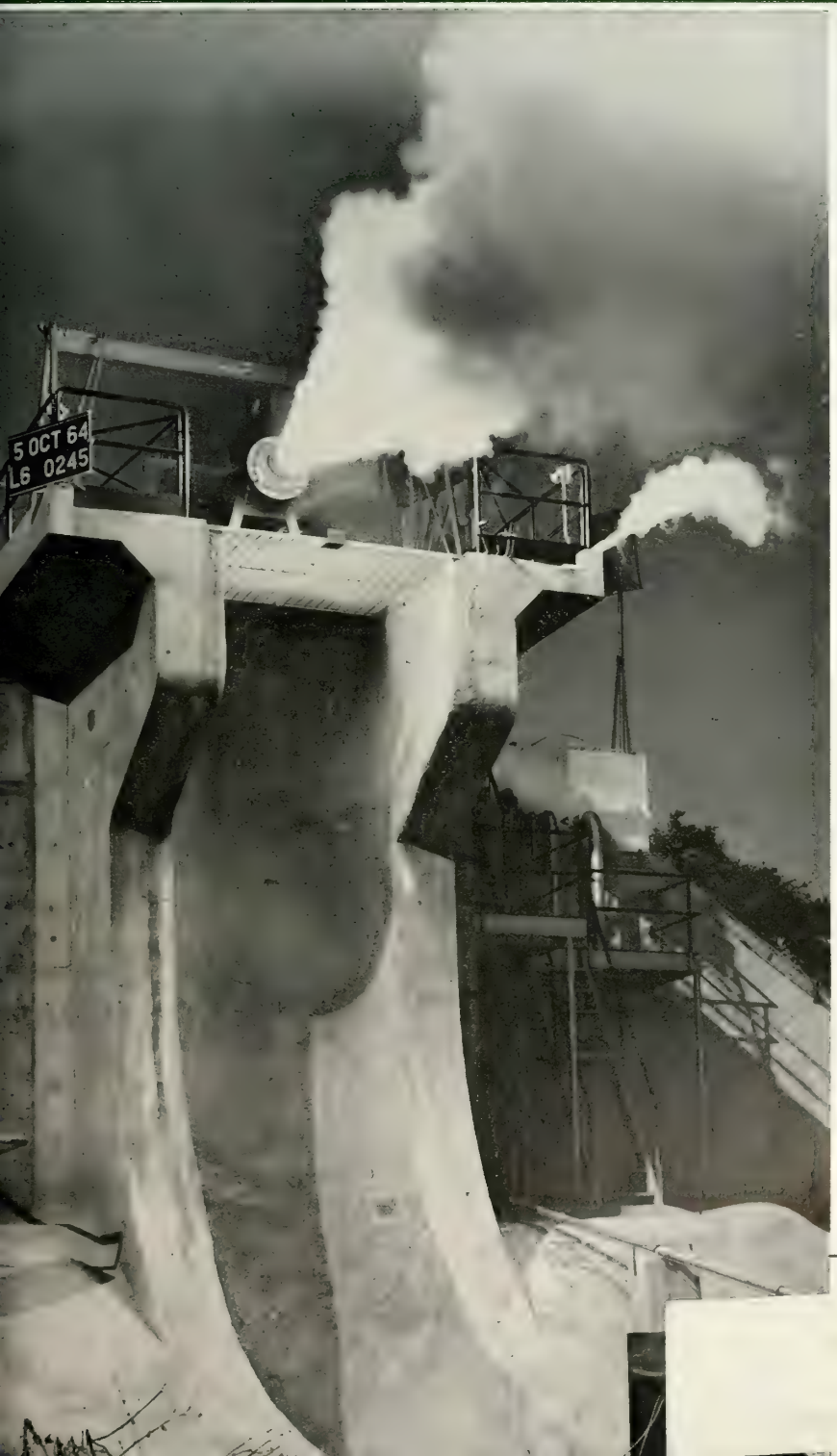
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THE WEEKLY OF SPACE SYSTEMS ENGINEERING

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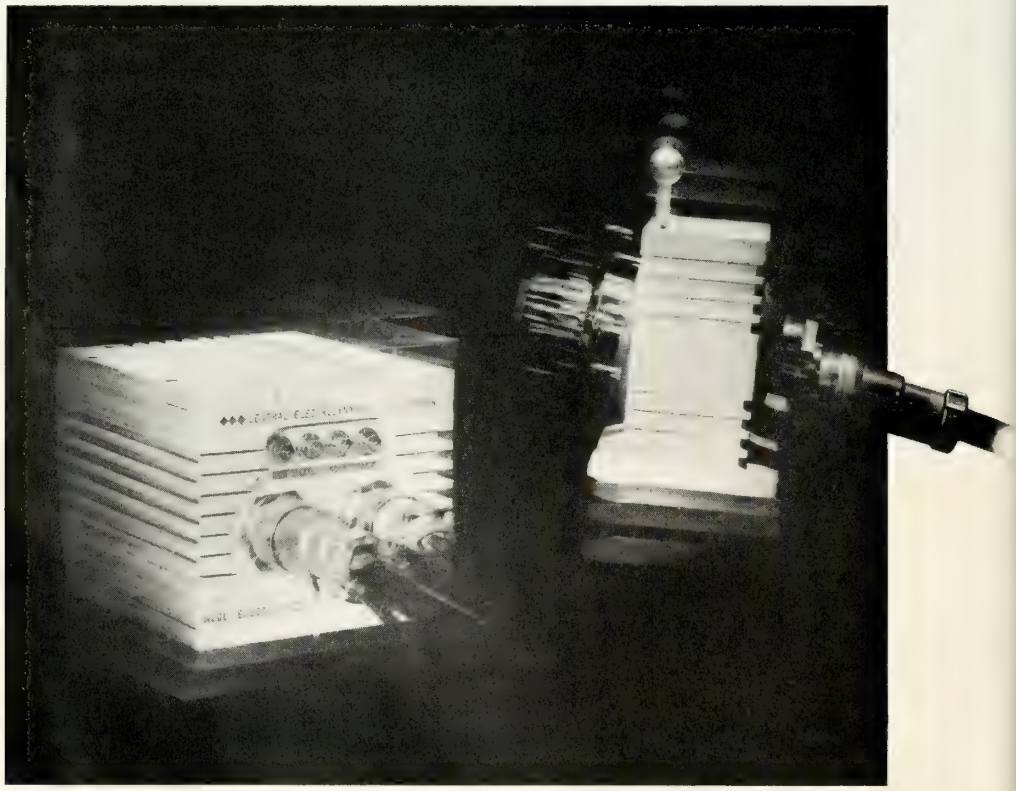
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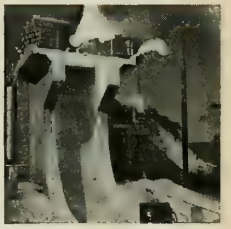
Published each Monday with the exception of the last Monday in December by American Aviation Publications, Inc., 1001 Vermont Ave., N.W., Washington, D.C. 20005. Cable Address: AMERAV.

Printed at Judd & Detweiler, Inc., Washington, D.C. Second class postage paid at Washington, D.C.
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THE COVER



Static firing of 18-in.-dia., 2,000-lb.-thrust hybrid engine at United Aircraft Corp.'s United Technology Center. Oct. 4. Hybrids work at UTC, Aerojet-General Corp. and Thiokol Chemical Corp. is treated in M/R's special report on hybrids technology beginning on p. 31.

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How to keep the upper hand . . . underground



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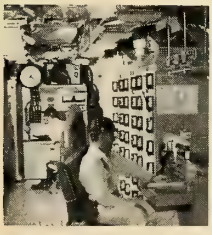


Production

In a plant near Ogden, Utah, Boeing assembles Minuteman missiles for the U. S. Air Force. More than 700 (all on or ahead of schedule) have already been delivered to launch or test sites. In a recent 120-day period, Boeing delivered a complete 150-missile wing to the Air Force.

Testing

Boeing crews have launched, or assisted the Air Force in launching, more than 50 Minuteman missiles from Cape Kennedy or Vandenberg AFB. In addition to developing launch procedures and maintenance techniques for Air Force crews, Boeing provides training equipment and technical assistance.





Weapon System Integration

As weapon system integrator, Boeing installs the missiles at operational sites and assembles the complete weapon system for delivery to Air Force. Work involves command and control equipment, communications networks, security installations and underground quarters for Strategic Air Command crews.

Minuteman II

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letters

230-Mc Band Far from Dead

To the Editor:

There was an excellent article in the Sept. 28 M/R ("Miniature S-Band Units Developed," p. 33) that described a new S-Band telemetry transmitter manufactured by Conic Corporation.

Unfortunately, the writer repeated some misinformation that has recently been circulating in the telemetering field, to wit: "With missile and space telemetry slated to move to S-band in 1967 . . ." This gives the erroneous impression that after 1967 guided missiles and space rockets will no longer be permitted to use the 230-Mc band for radio telemetry. Other equally unfounded rumors put the cut-off date at 1970. Actually, neither of these stories is true, and there is no cut-off date for telemetry use of the 230-Mc band. The government has stated its intention to continue to allocate telemetry channels in the 230-Mc band after 1970.

I think you could perform a very good service by permitting your readers to know of the continued use of the 230-Mc band for telemetering. This is important because of the costly planning and procurement that would be required by the different system performance caused by the difference of propagation of microwaves vs. VHF signals.

Albert Rolande
Melbourne, Fla.

X-15's Base

To the Editor:

In your "Shots of the Week" section in the issues of Sept. 14 and Oct. 5 you stated that the *X-15* flights of Sept 3, 28 and 30 occurred at Vandenberg AFB, Calif. This is an error, since everyone knows that the *X-15* program has only been conducted from Edwards AFB, Calif.

Victor H. Sternberg
Captain, USAF
Lompoc, Calif.

Everyone, including us. It must have been gremlins.—Ed.

British Aerospace

To the Editor:

I feel that your editorial "Farnborough Revisited" (M/R, Sept. 14) is rather unnecessarily hard on the British aerospace iindustry. Although I am not myself in direct contact with the above industry, and my information may thus be a little dated, I feel that I might argue with you on a number of points.

Firstly, I see that you do not mention our antiaircraft missile—*Bloodhound*—at all, although this is the backbone of our long-range air-defence system. I am informed that the radar of this missile is second only in power to that of your own Multifunction Array Radar, as intended for *Nike-X*. Coupled with alternative nuclear or HE warheads, surely this makes *Bloodhound* an effective weapon?

I recall that it is generally accepted, in this country at least, that the combination of the *Lightning* F3 and the *Red Top* collision-course missile is one of the most effective weapons systems in the world. I remind you of the occasion when, a few years ago, contrary to an American boast, an early mark of *Lightning* had no difficulty in sitting on the tail of a U-2 at 10,000 ft., only a few minutes after take-off.

I remind you also that we have had a very effective antitank missile—*Vigilant*—in service for some years, whereas your own antitank missiles are not yet operational.

I feel also that your remark about Rolls Royce leaning heavily on NAA in making the RZ2 engines needs to be qualified. A few weeks ago, I visited the Ministry of Aviation Rocket Propulsion Establishment, where much of the early development work on the RZ2 was carried out. While there, I was informed that as far as the RZ2 was concerned, the original idea was for NAA to supply about 90% of the know-how, and for Rolls Royce to fill in the remaining 10%, whereas in fact the reverse had happened, and Rolls Royce had supplied about 90% of the required technology. If this is true, then Rolls Royce was hardly leaning heavily upon NAA.

I feel also that I should contend your statement that *Blue Streak* compares unfavorably with *Thor*. In the first place, *Blue Streak* has about 1¾ times the thrust of *Thor*, and also, in the present design of the ELDO booster using *Blue Streak* as its first stage, the design allows for 2,500 lbs. to be put into low orbit. With the use of an LH_2 upper stage, this would rise to about 5,000 lbs. in low orbit. This compares with *Thor-Delta's* capability of about 1,000 lbs., and *Thor-Agena's* 1,600 lbs. in low Earth orbit. Hardly a comparison detrimental to *Blue Streak*, which would appear to be somewhere between *Atlas* and *Thor* in payload capability.

Although I agree with you that Britain has not got the funds available to indulge in a vigorous missile/space programme, it occurs to me that when we do decide to go ahead with a project, we generally make a good job of it. Witness a few recent British inventions:

Radar, steam catapult and angled deck (on aircraft carriers), small surface-to-air and air-to-surface rockets (World War II), and a useful part of the first atom bomb (for better or worse).

Nigel Barak
Marlborough, Wilts.
England

The Gauntlet

To the Editor:

Many cheers (and, I hope, Congressional eyes) on your excellent editorial "The Gauntlet" in the Oct. 10 M/R. Your editorials are always superior.

Steve Reed
Port Hueneme, Calif.





Out of this canister comes "instant glider"

Packed in a 33-inch canister, the paraglider is carried into space by a rocket. At about 300,000 feet, it is released and the inflation sequence begins.

When inflated to its full size, (18-foot wingspread, 14-foot length) the paraglider ascends to 600,000 feet before it begins its descent. Instrumentation will yield data on micrometeoroid behavior.

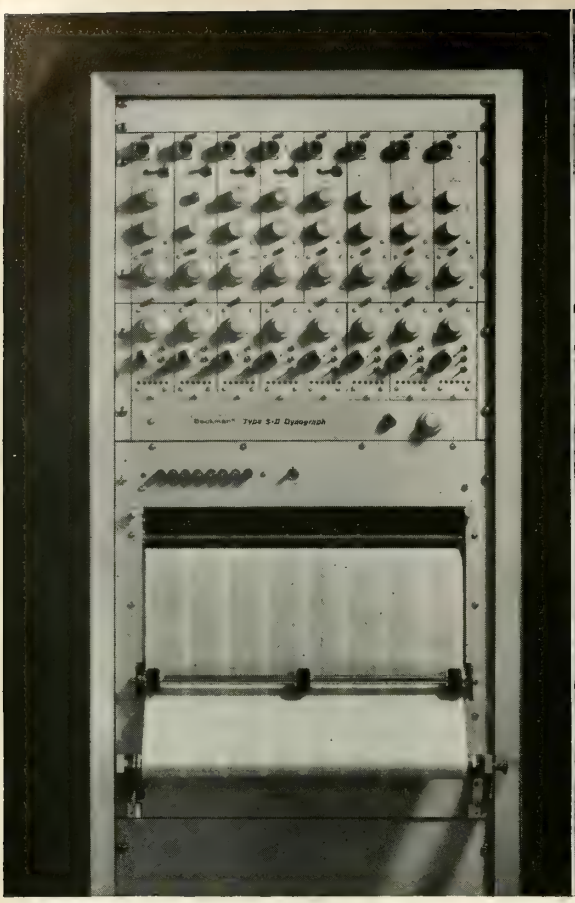
To produce this vehicle, BFG engineers developed a special high temperature fabric lamination for the inflatable frame. Made of glass fiber coated with silicone resin, it is designed to withstand temperatures up to 1150°F for about 20 seconds. Membranes or "sails" are attached to the inflated tubes.

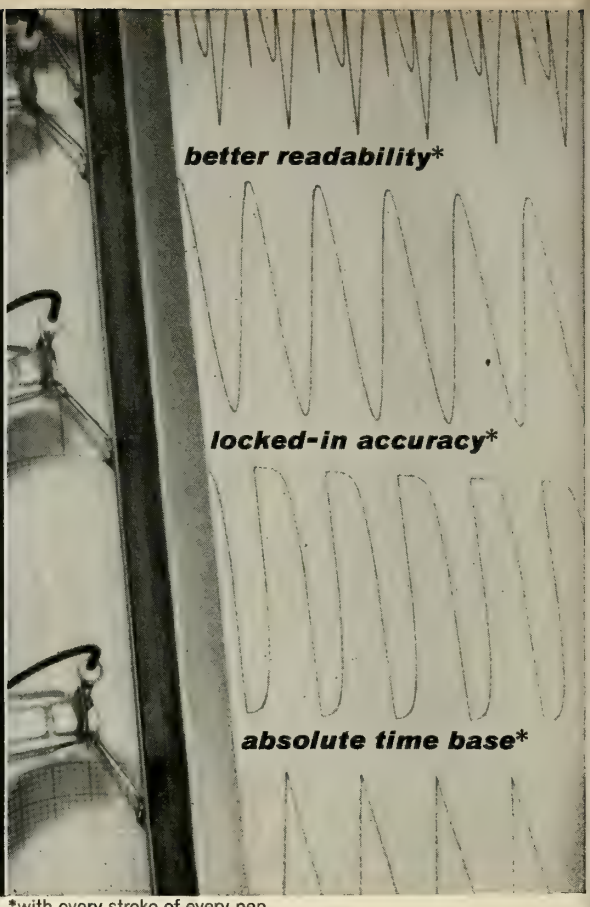
The paraglider was produced for the National Aeronautics and Space Administration by B.F.Goodrich in conjunction with Space-General Corporation, the prime contractor. A Space-General Aerobee 150 rocket furnishes propulsion. The project is managed by NASA Langley Research Center, Hampton, Va., under the over-all direction of NASA's Office of Advanced Research and Technology.

The paraglider is just the latest example of B.F.Goodrich know-how in inflatable products: Tires, De-Icers, Shock Attenuator Systems, Pressure Suits. If you have similar requirements, check with *Department MR-11, B.F.Goodrich Aerospace and Defense Products, a division of The B.F.Goodrich Co., 500 S. Main St., Akron, Ohio 44318.*

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SPECIFICATIONS

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Frequency Response	DC to 150 cps
Linearity	±0.25%, or less
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Input Impedance	1 megohm DC; 1 megohm shunted by 1,000 p.f. or less AC.
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The Countdown

WASHINGTON

Pershing Battalion Increase Studied

An increase in the number of *Pershing* battalions now programmed is under consideration in the Dept. of Defense. Army officials would like more of the field army missiles—particularly in view of the large numbers of Soviet surface-to-surface battlefield missiles. No decision has yet been made. *Pershing* production is being stretched out, however, to leave this option open.

Mariner Experiment Seen as Marginal

Measurement of scale height and pressure of the Martian atmosphere by the *Mariner C* occultation experiment could be very imprecise. If tolerances specified for various parts of the communication system should all be at their negative values, the received signal could be severely distorted by noise. This would reduce measurement precision greatly. Doppler frequency and amplitude changes to be measured occur only during a very short time period, and so cannot be integrated in the manner used for conventional deep space tracking.

NASA Has New Multibillion-Dollar Plan

NASA Administrator James Webb told a Huntsville, Ala., group that the space agency is considering a new ten-year program which would cost from $7 to $15 billion in the period from 1965 to 1975. He did not detail the projects he expects to be included. But it is believed he was referring to the *Apollo-X* spacecraft with a one to two-month orbital capability, extended exploration of the Moon with the LEM Truck spacecraft, unmanned exploration of Mars with the *Saturn IB* launch vehicle and *Voyager* spacecraft, and an Earth-orbiting space station with a six-month-to-one-year lifetime.

New Look at Competing Launch Vehicles

NASA and the Dept. of Defense are taking a new look at launch vehicles which can be considered competitive. These include the *Thrust Augmented Delta, Atlas-Agena, Atlas-Centaur* and *Titan II*. NASA Administrator Webb says only one or two of these may eventually be retained. He also says *Saturn IB* and *Titan III* compete in certain areas of payload capability. But he adds that it is still too early to decide whether to keep both or cancel one.

Floxed Atlas May Be Dropped

NASA's Floxed *Atlas* development program is being stretched out and may be in danger of being canceled. Space agency officials told COUNTDOWN that the Phase I program, which was to end this year, will now be continued until mid-1965. As a result, only $2 to $3 million will be spent on it in FY '65. Also delayed is the decision whether to move on to Phase II, which called for development of flight hardware and two flights in the 1966-67 period.

Canard Stabilizers Studied for X-15

NASA's Flight Research Center has completed a series of wind-tunnel tests of *X-15* models with canard stabilizers mounted on the nose. Purpose: to see if a canard surface would permit the *X-15* to re-enter the atmosphere at higher angles of attack. This would cause more rapid deceleration, enabling the research craft to go to higher altitudes without exceeding its design temperature limit on re-entry. Tests were carried out in a Jet Propulsion Laboratory tunnel.

Society Cancels MOL Meeting

Cancellation of the American Astronautical Society's proposed Nov. 18-19 Cambridge, Mass., meeting on the *Manned Orbiting Laboratory* is not regarded as a pessimistic sign for the program (see p. 14). The group was told the principal government speakers would be unavailable. Best bet: date of the session corresponds too closely with the expected announcement of a go-ahead for *MOL*, therefore is considered premature.

DASA Funds Project Spindrift

Defense Atomic Support Agency has awarded a $108,307 contract to Electro-Optical Systems in a classified program—Project Spindrift—which will involve development of rocket vehicles and telemetry gear. Phase II of the program, which is believed to involve firing of sensor rockets through the plume of spray that would be thrown up by an underwater nuclear explosion, calls for funding of more than $400,000.

INDUSTRY

Lockheed Unveils MOL Team

Lockheed Missiles and Space Co. has named the principal subcontractors selected as partners in its bid for the Air Force's *Manned Orbiting Laboratory*: RCA (telemetry, tracking, communications and data management subsystems), General Precision, Inc. (navigation and guidance system), Garrett/AiResearch (life support and environmental control systems).

Contract Management May Be Consolidated

Industry in the future may deal with a single government contract manager in each of 11 contracting regions throughout the U.S. A pilot study called Project 60 now is under way in the Philadelphia area. Under this setup, rather than each contractor dealing with Army, Navy, Air Force and NASA contract managers, he would have dealings only with a single government manager.

INTERNATIONAL

Soviets To Show New Rockets

Press dispatches from Moscow indicate the Russians planned to unveil five new rockets in the Revolution Day parade. Among these was a missile described as about 82 feet long and presumably liquid-fueled. This could be the new Soviet storable-fuel ICBM. Three surface-to-surface tactical missiles and one surface-to-air missile also were expected to be shown for the first time.

Nitze Discusses ASW

Advancement in anti-submarine warfare will be a "slow, disciplined, step-by-step integration of literally hundreds of small increments of operational and technical progress," predicts Secretary of Navy Paul H. Nitze.

Addressing a Navy League session in Richmond, Va., Nitze admitted that the lack of a major breakthrough in ASW technology presents a bad record to date. He outlined, however, several steps taken by the Navy to improve chances for an early breakthrough in this area. Among these have been administrative changes—the appointment of an ASW executive director reporting to Adm. David McDonald, Chief of Naval Operations, and the naming of an ASW systems manager under the Chief of Naval Material (M/R, Sept. 21, p. 24).

Progress in ASW "will be accelerated as the new organization continues to operate more and more smoothly," said Sec. Nitze.



Martin Gets $40M for Sprint

The Martin Co. has received a $40-million contract award from the Bell Telephone Laboratories for continued development work on the *Sprint* anti-missile missile.

The contract brings to $119 million the value of Martin's share in the program. *Sprint* work is being performed at Martin's Orlando Div.

Shots of the Week

The Air Force launched a *Minuteman II* ICBM from Cape Kennedy Oct. 29 on a trajectory that carried it into a target area 5,000 mi. down the Eastern Test Range. Launch was conducted by the 6555th Aerospace Test Wing.

- NASA test pilot Milton Thompson flew *X-15* number 3 from Edwards AFB, Calif., Oct. 30 in a mission to record noise level of air rushing along the side of the rocket plane's fuselage.
- The Navy successfully fired a *Polaris A-3* missile from the nuclear submarine Pulaski on Oct. 31.
- A Strategic Air Command crew from Malmstrom AFB, Mont., successfully fired a *Minuteman* ICBM from Vandenberg AFB, Calif., on Nov. 4. The missile, the 70th *Minuteman* to be launched from Vandenberg, traveled 5,000 mi. down the Western Test Range.

Goddard Papers Go to Clark

The papers of Robert Hutchings Goddard have been given by his widow to Clark University, Worcester, Mass., the space pioneer's alma mater, where he later served as professor of physics. By 1968, Clark will house the collection permanently in a $3-million memorial and academic center built to honor Goddard

UTC Tests Titan III-C Motor

United Technology Center successfully tested the thrust termination system of the 120-in. solid motor during a static firing at Edwards AFB, Calif. The motor—being developed for the *Titan III-C*—had a

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burn time of a little more than 6 minutes.

In the test, the two circular steel ports in the forward section of the rocket were blown out five seconds after ignition. This permitted exhaust gas to escape from both ends of the five-segment solid, thus neutralizing thrust.

The thrust termination system is considered essential since *Titan III-C* is a man-rated vehicle.

Value Engineering Session Set

The Defense Dept. will hold the first Value Engineering Symposium for Advancement in the State of the Art on Nov. 18-19 at Redstone Arsenal, Ala.

Representatives of industry, government and universities will participate in the session, sponsored by the Army Missile Command. Fifteen technical papers will be presented in areas of design, development, production, management and administration.

Deputy Assistant Defense Secretary George E. Fouch will deliver the keynote address.

Glenn To Retire

Navy Secretary Paul Nitze has approved the retirement of astronaut John Glenn, who just last week was promoted to full colonel in the Marine Corps.

Glenn's retirement date is to be effective Jan. 1 if it is not delayed for medical reasons. He recently accepted a civilian job with the Royal Crown Cola Co., a Georgia soft drink firm.

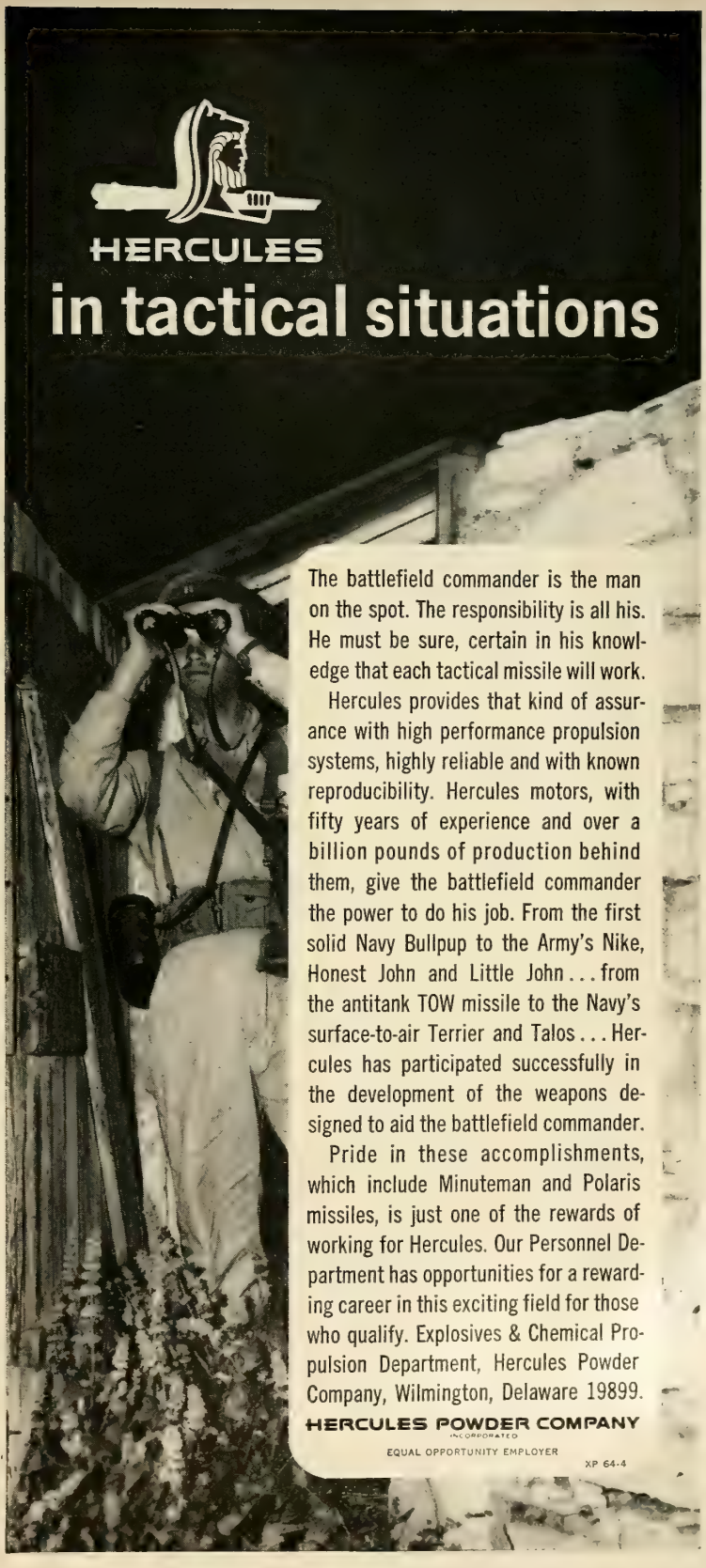
Capt. Theodore C. Freeman

Air Force Capt. Theodore C. Freeman, the astronaut trainee killed in a jet trainer crash near Houston Nov. 1, was buried in Arlington National Cemetery Nov. 4.

Statehouse Beckons AC Official

Taylor Benson, assistant director of public relations for AC Spark Plug Div. of General Motors in Milwaukee, has been elected to the Wisconsin State Senate.

Benson, a Democrat representing Wisconsin's 28th District, will continue in his present position with AC Spark.



Circle No. 6 on Subscriber Service Card

European Comsat Plan Advances

System cost estimated at 'tens of millions'; proposals indicate a new organization may replace or supplement ELDO, ESRO

by Frank G. McGuire

GENEVA—European planners have set 1970 as the target date for operational status of the communication satellite system they may develop and operate independently of any U.S. system.

Proposals presented at two closed-door October sessions of the European Conference on Satellite Communications pointed up a strong interest in keeping an independent option for Europe, despite the existence of agreements with the United States.

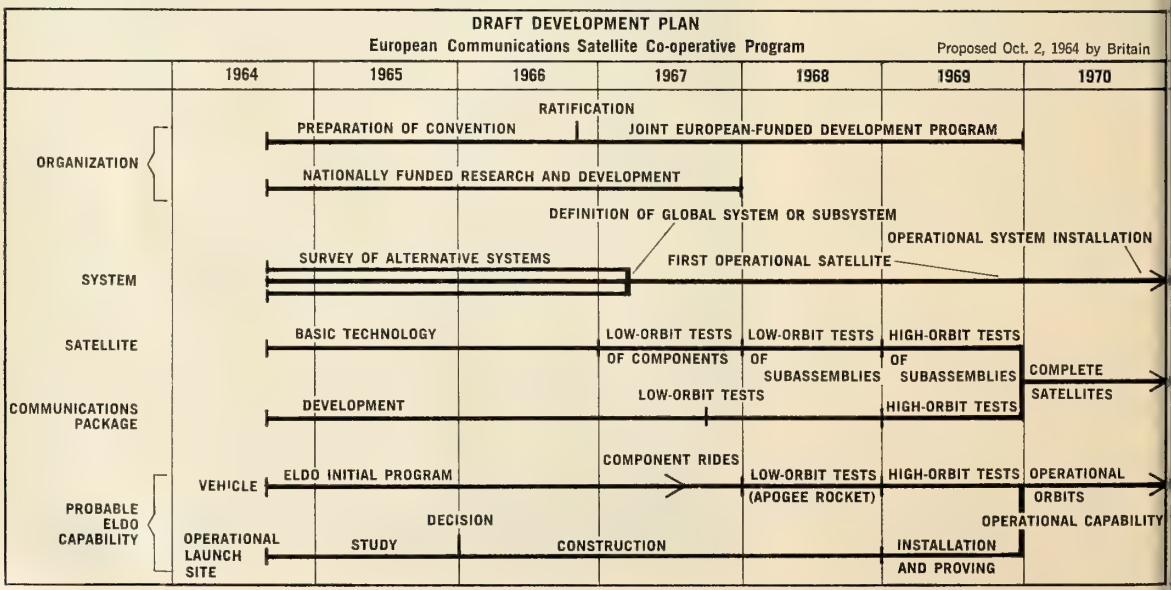
Probability that a new organization will be created to either replace or supplement the European Launcher Development Organization (ELDO) and the European Space Research Organization (ESRO) figures prominently in these proposals, which were first put forward by Great Britain in early October and were supported by nearly all the conference members at the end of the month.

The joint program would have a fully operational satellite system in space by 1970, taking advantage of the ELDO booster capability for launching and the ESRO capability for payloads. Nationally funded R&D would play a large part in the program, with joint costs covering only launch vehicle and payloads. Ground stations would be installed on a purely national basis.

Germany has proposed that a widespread fabrication and test base be set up for the program, similar to the multi-national base on which the F-104 program was built.

Britain's draft development plan calls for a survey of alternate systems until spring, 1967, when a final design would be chosen. At the same point a choice would be made for a global system or a regional subsystem.

Cost of the program has not been firmly established, and officials will estimate it only as "tens of millions of dollars."



• **German plan**—The proposal by Germany "based on the assumption that ECSC will establish an organization at an early date (new organization or, as is being considered, in conjunction with ESRO/ELDO)," places great emphasis on a regional European network but does not rule out a global system.

Timetable of the initial phase of the German plan was considerably faster-paced than the British plan. Germany would like studies of Europe's traffic needs, a regional or global system, satellite specifications, launch vehicles, launch site, and cost estimates —all completed by the end of next year. These studies would then be acted upon as soon as possible and work begun.

Britain's plan calls for these surveys to run until spring, 1967, when a decision would be made.

A decision on the optimal European subsystem, coordination by ECSC of work assignments for R&D, preliminary selection of components and subassemblies, and finally the choice of launch vehicles for component flight tests would follow the studies in rapid order.

In this phase, German and British plans are similar, since both timetables call for component flight tests in the 1967-68 period.

The German plan apparently does not rule out the possibility of continued participation in a worldwide system in cooperation with the U.S., while a regional system for Europe is also set up.

Flight-testing of components and subassemblies for the European subsystem would, according to the German proposal, be done in various countries using their own or ELDO/ESRO facilities. Meanwhile, flight-testing of components would be done with *ELDO A*, *Diamant* or U.S. launch vehicles (probably *Scout*), preferably in conjunction with other projects in order to keep costs of flight-testing down.

The flight-testing will not necessarily be carried out at the same high altitudes planned for the operational satellites.

The selection of components, based on findings of the flight-test program, would be carried out with a view toward their possible application in a worldwide system as well as the European subsystem.

Manufacture and flight-test of prototypes, slated for 1968-70, would involve two or more satellite models, separately tested for machanical and electrical properties. These would be the responsibility of two or more countries in the program.

These payloads would be launched aboard the *ELDO A* vehicle or a NASA booster, with telemetry and tracking handled by ELDO/ESRO and perhaps NASA ground stations.

Some Key GOP Legislators Lose

AMONG THE LOSERS in the Nov. 3 elections were a number of Republicans holding key positions on Congressional committees dealing with defense and space affairs.

The House Science and Astronautics Committee lost several high-ranking Republicans: J. Edgar Chenoweth (Colo.), William K. Van Pelt (Wis.), and R. Walter Riehlman (N.Y.). James D. Weaver, a first-term GOP Congressman from Pennsylvania, also was defeated. Neil Staebler's unsuccessful gubernatorial bid in Michigan left the only empty seat on the Democratic side of the table.

Four Republicans and five Democrats will not return to the House Armed Services Committee in the 89th Congress because of election defeat, death or retirement. Democrats retiring are Chairman Carl Vinson (Ga.), Richard E. Lankford (Md.), and Joe Kilgore (Tex.). Republican Frank J. Becker (N.Y.), is also retiring. These committee members lost their House seats: Arthur Winstead (D-Miss.), George Huddleston (D-Ala.), Frank Osmers (R-N.J.) and Edgar Foreman (R-Tex.). Walter Norblad (R-Ore.) died in office.

Similarly hit was the House Appropriations Committee, which lost its chairman, the late Clarence Cannon (D-Mo.), earlier this year. Two ranking Republicans, Ben F. Jensen (Iowa), and Walt Horan (Wash.), were defeated, along with these lower-ranking Republicans: John R. Pillion (N.Y.), Earl Wilson (Ind.), William H. Harrison (Wyo.), and Louis Wyman (N.H.). Harold C. Ostertag (R-N.Y.), retired.

Rep. Riehlman, space committee member who was defeated in his try for re-election, is also lost as ranking Republican on the Military Operations subcommittee of the House Government Operations Committee. Rep. William Stinson (R-Wash.) another Operations Committee member, also met defeat.

The Senate Armed Services committee lost two of its six Republicans, Barry Goldwater (Ariz.), and J. Glenn Beall (R-Md.), defeated by Joseph Tydings.

The Senate Space committee lost one on each side: Kenneth Keating (R-N.Y.) who was defeated, and J. Howard Edmondson (D-Okla.) who did not run. The Senate Appropriations and Government Operations committees both had only the single change, in the vacancy left by Vice-President-elect Hubert Humphrey.

The Joint Committee on Atomic Energy lost a junior member, Rep. Jack Westland (R-Wash.), who was defeated.

An alternative to the F-104-type multi-national program of joint fabrication of portions of a complete unit is the parallel manufacture of complete satellites in several countries or groups of countries.

The plan put forward by Germany includes provisions for launching of operational satellites for the European satellite subsystem after agreement with the interim committee set up in Washington as part of the recent comsat agreement signed by the U.S. and Europe. It also provides for delivery of European hardware under this program to the global system.

• **Netherlands plan**—Supporting the idea of a separate European communication satellite system, the Netherlands proposed to extend its existing program of supplying telemetry for the ELDO launcher to provide similar services for the comsat network.

The planned national program in support of the proposed joint undertaking includes work on telecommunications packages, including microwave links; the telemetry system, a miniaturized digital type similar to that of the ELDO system; control systems, including servo circuits, sequencers and computer circuits; reliability research on electronic components; and machanical structures, including study of optimized design, material choices, strength and stiffness, vibration, heat balance and the effect of environment.

The Netherlands also proposes to make a laboratory model of a communications satellite based on advanced techniques expected to be sufficiently developed and tested by 1969. The characteristics of the design would be kept flexible enough for adaptation to future requirements.

Estimated cost of the Dutch portion of the program, as outlined, would be about $420,000 annually.

• **Danish plan**—Estimating its contribution at 10 scientists and a total of $140,000 up to March 31, 1966, Denmark has proposed to take on the development of tracking, attitude and orbit control, including telemetry; mechanical devices such as bearings linkages; multiple access problems; receiver; signal processing unit; transmitter; and prototype construction. ■

Welsh Reports MOL Program Is Due To Get Program Definition Okay Soon

by Hal Taylor

HOUSTON—A top White House official says the *Manned Orbiting Laboratory (MOL)* program will move to the program definition phase this month. This report came as the Air Force revealed new technical details of the two-man spacecraft.

Dr. Edward C. Welsh, executive secretary and acting chairman of the National Aeronautics and Space Council, told MISSILES AND ROCKETS that "there is no question in my mind that the program will get the go-ahead signal." Welsh, here for an address before the jointly sponsored AIAA/NASA Third Manned Space Flight Meeting, said he did not believe the program will be changed because of the recent orbiting of three cosmonauts by the Soviet Union.

At the same time, Col. Donald Heaton of the Air Force Space Systems Div., told the meeting that the AF had decided on a 14-ft., two-compartment laboratory. The larger compartment will contain military and scientific equipment and the astronauts' living quarters. The smaller compartment, on the front end of the laboratory, will serve as an air lock directly next to the *Gemini B* ferry vehicle. He also reported that cutting a hole in the *Gemini* heat shield appears to be the best method of permitting astronauts to move from the spacecraft into the laboratory.

In other highlights of the meeting attended by more than 1,000 scientists and engineers:

—Brig. Gen. Joseph S. Bleymaier of the Air Force Space Systems Div. said that eight launches of the *Titan III-C* are now planned from Pad 41 at Cape Kennedy, beginning in the fall of 1965 and covering a period of nine months. These will be preceded by four launches from Pad 40 beginning in the spring of next year. He also said that nine satellite payloads will be injected into orbit by seven *Titan III-C* launches, including a just-approved MIT communication experiment—a 45-in. radar calibration sphere which will be placed into a 2,000-n.-mi. orbit.

—Dr. George E. Mueller, NASA associate administrator for manned space flight, said the agency is currently reviewing its program in the light of the recent Russian three-man orbital flight. "Personally, I feel we have a well-rounded program and if it is continued on the present level, we will achieve the space capability we want for the nation." He also declared that he is strongly recommending that the U.S. take advantage of the extended orbital capability of the *Apollo X* vehicle. In an apparent retort to recent criticism by the Space Sciences Board of the National Academy of Sciences of alleged overemphasis on manned spaceflight, he also declared that there is no such thing as unmanned exploration of space—"the only question regarding man is his location."

—Welsh said that space expenditures over the coming years, even with an occasional plateau, will be characterized by an upward trend. This growth, he said, should be consonant with the growth in the gross national product. In an interview later, he said that while he does not expect a sharp rise in next year's space budget, this does not mean that advanced programs cannot be initiated. Another high Administration official said he doubted seriously that NASA's FY '66 budget would reach $5.5 billion.

—Charles W. Mathews, director of Project *Gemini*, said he expects to get the *Gemini-Titan II* launch off before December. Only a two-pad launch capability could speed up the flight schedule appreciably for *Gemini*, he said. McDonnell and NASA crews are now working three shifts, seven days a week, on the spacecraft where such three-shift operations are beneficial. Martin is working on a two-shift, five-day week providing the launch vehicles.

● **MOL report**—In discussing the *MOL* program, Heaton said that the laboratory structure could consist of a simple foam-filled aluminum truss core sandwich for adequate strength, coupled with effective environmental control. In addition to providing strength adequate for launch and environmental protection in orbit, the structure should also accommodate flush-mounted thermal radiators and other devices which must be exposed to space to avoid, if possible, protuberance beyond the surface of the vehicle.

He said that the front-runner among methods for crew transfer between the *Gemini B* and the laboratory appears to be a hole in the heat shield. He added that while this approach requires more specific configuration testing than lesser-ranking alternatives—an expendable external tunnel or rotating the *Gemini* to a side-by-side position to mate hatches—it presents the lowest technical risk and fewer possibilities of failure modes.

"As to electrical power, adaptations

'Standards' Eased

A SLIGHT but significant shift in the Defense Department's attitude toward the standards of conduct amendment has been indicated. Leonard Niederlehner, deputy general counsel, was quoted in an interview last week as saying the Department was not interested in "trifles."

Specifically mentioned as being below DOD notice were calendars and tie clasps. The first were counted as a form of institutional advertising and tie clasps as of little value unless they were made of "precious" metal. The Defense official said the directive is designed to prohibit contractors' paying for lavish entertainment.

Further confusing the issue is Niederlehner's comment that alternate lunches are acceptable. That is, a DOD employee can go to lunch with a contractor and the contractor pay for it if the next time they go to lunch the DOD employee pays for it.

The amendment as now written, however, forbids the acceptance of "any" gift, gratuity or entertainment from any firm or individual doing business with, or seeking to do business with DOD.

Niederlehner also denied that the amendment, which becomes effective Nov. 24, reflects unfavorably on either military or civilian DOD personnel.

of existing *Gemini* or *Apollo* fuel cells could prove satisfactory for the initial program. Growth toward larger stay times for possible follow-on programs could exploit improved fuel cells, solar panels or isotope power sources. The follow-on mission, its timing and requirements for attitude control, stabilization and in-orbit maneuvering—as well as duration—will determine the choice among these alternatives."

He said there has been a long debate over whether *MOL* should use a one- or two-gas environment. "Consideration is being given to providing an environmental control system capable of either a 5-psi all-oxygen or a 7½-psi mixed-gas atmosphere and structure capable of withstanding the higher pressures. Initial operation may be with all-oxygen, with inert gas being introduced later."

"From the standpoint of the interface between the *Gemini B* and the laboratory," Heaton continued, "the laboratory vehicle will supply the electrical power and any pressure and thermal atmosphere needed by parts of *Gemini* during the period of laboratory orbital operations when the *Gemini* is on standby status. Fine attitude control, translation, and stabilization in orbit will be provided by an orbital attitude and maneuvering system integral to the laboratory system."

● **Contract rundown**—In discussing the Phase I pre-program definition contract work, he said the contracts were awarded to the Martin Co. on the *Titan III* chiefly to obtain launch-environmental parameters and performance for a selected trajectory envelope, and with McDonnell Aircraft Corp. on preliminary definition of *Gemini B*.

Contracts were negotiated with the Garrett Corp. and Hamilton Standard on the *Gemini, Apollo* Command Module and *Apollo* Lunar Excursion Module environmental control systems. Honeywell studied the problems of adapting the *Gemini* and *Apollo* attitude control and stabilization systems to *MOL*, and General Electric investigated the feasibility of adapting to the *MOL* both the *Gemini* fuel cell and other power sources, such as solar cells and nuclear and solar dynamic systems. North American Space and Information Systems Div. developed data on the fuel cell system in *Apollo*, and Allis Chalmers covered advanced fuel cell possibilities. ■

Apollo's Military Potential Detailed

HOUSTON—Military potentials of the three-man Project *Apollo* spacecraft were spelled out here for the first time by Dr. George E. Mueller, NASA associate administrator for manned space flight.

In a last-minute revision of his prepared speech at the AIAA/NASA meeting, Dr. Mueller declared:

"The elements of capability being created in the *Apollo* program will be available to fill other military requirements as they emerge.

"For example, the *Apollo* spacecraft includes a Command Module that provides a shirtsleeve environment and sufficient room for three men to live and operate for periods of at least two weeks in space. With minor changes, sufficient food, water, air and other supplies can be carried to increase that time considerably.

"The combination of the maneuverability provided by the Service Module and the aerodynamic features of the Command Module makes it possible for the *Apollo* crew to land within a few miles of any . . . area on the Earth. . . .

"The *Apollo* spacecraft also includes a Lunar Excursion Module (LEM) that has several potentialities. In the *Apollo* mission, this module is employed to transport two astronauts from the Command Module in lunar orbit to the surface of the Moon. It guides them to the landing area, hovering and translating a quarter mile or so while the pilot selects an exact landing point, and then landing.

"This spacecraft, the first designed and built for operation completely outside the Earth's atmosphere, has a number of structural advantages over spacecraft which must return through the atmosphere. One of these advantages is increased internal volume. It appears possible for astronauts, by increasing the amount of expendable supplies, to extend considerably the period of time they can spend in space. In Earth orbit, the sensors and guidance and propulsion systems of the Lunar Excursion Module will permit it to leave its mother ship, make rendezvous with any other satellite, 'land' on the satellite, allow the crew to get out and inspect, repair or test the other satellite, and then take off and return to its mother ship. This could thus be used for rescue operations . . ."

● **Step toward space station**—"The *Apollo* spacecraft, therefore, provides the nation with a precursor to a true space station. The Lunar Excursion Module is a test bed with which it will be possible to establish the constraints, evaluate the feasibility, and demonstrate the solution of most of the operations required for space exploration of very long duration.

"Another important capability being created in *Apollo* is experience and know-how in manned space flight operations. A space vehicle in Earth orbit travels at a speed of five miles a second—300 miles a minute. For a flight into deep space, a speed of seven miles a second or 420 miles a minute is required. For the split-second operations required in such a regime, man and machine must be married to an unprecedented degree. For this purpose, we are pioneering in the operation of appropriate control mechanisms, using the worldwide manned space flight network, and central switching terminal at Goddard Space Flight Center in Maryland, and the Deep Space Network of the Jet Propulsion Laboratory, all under the control of the Mission Control Center at the Manned Spacecraft Center in Houston."

● **MOL needed, too**—"There is one misconception in the national security area that I would particularly like to discuss. The national security benefits from the manned space flight program have been described in some quarters as 'spin-off' or 'fall-out.' I believe such a description misses the point completely.

"The capability to conduct manned space flight activity did not exist in the United States six years ago.

"Later in the *Apollo* program, we will have the *Saturn I-B* and *Saturn V* launch vehicles . . . the *Saturn V* will enable us to make a quantum jump in launch vehicle capability . . . It will be possible to place in Earth orbit a 36-man station . . . or launch a six-man station at an altitude of 23,000 miles over-looking a fixed area of the Earth."

Mueller said his proposed military applications did not mean he was advocating that the Air Force's *Manned Orbiting Laboratory* be dropped. "We need them both," he declared.

"It is not my place to discuss military missions. It is my understanding that the Department of Defense has not yet determined specific requirements in this area. Pending the establishment of these requirements, however, the work in progress by NASA is providing for the national security by creating the capability to do what is needed to fill requirements that may emerge in the future," Mueller said.

"In summary, therefore, we are approaching the time when the United States must make another major decision regarding the course of its activities in space. When we pass the peak of effort in *Apollo*, the capability that has been created will be available for future undertakings."

Systems Integration Contract Forbids Firm from Bidding on Hardware

A TOUGH hardware-exclusion clause has been accepted by TRW/-Space Technology Laboratories as part of the systems integration and developmental test support contract the company has negotiated with the Navy's Anti-Submarine Warfare Systems Project.

Although the estimated $5-10 million contract had not been signed as MISSILES AND ROCKETS went to press, it was known that the company has acceded to the Navy's feeling that such a clause was a *sine qua non*. Adm. Charles B. Martell, director of the Navy's ASW programs, is known to feel strongly that the Navy must avoid the Congressional criticism that has been leveled at military use of industrial support contractors—particularly in the Air Force ballistic missile programs.

The STL mission will be completely unlike the systems engineering support it has furnished to the Air Force. "It will more closely parallel the type of thing that Vitro does for us on the surface missile programs," Martell says. More specifically, STL will provide analysis of equipment and interface problems and recommendations on the solution of technical problems.

● **Tight Navy control**—Systems engineering and management as well as technical direction will remain securely with the Navy, and more particularly in the hands of Adm. C. A. Karaberis, ASWS project manager. "STL will be a technical consultant to the Navy and no more," according to one Navy official.

In line with the systems engineering for ASW, Navy officials feel that STL will become involved in analyses of the effectiveness of ASW equipment and operations—making recommendations on methods to improve both. Another area, stemming from the requirement for equipment and operations analyses, is expected to involve recommendations to the Navy on training and training requirements for the personnel manning ASW systems in the fleet.

Finally, STL will play a role in the technical evaluation of requirements and perhaps even in the formulation of requirements, again purely as an advisor to Adm. Martell or Adm. Karaberis.

● **Hardware exclusion**—Prohibiting a company from bidding on components or systems for which they have served as a systems engineering or consultant to a government agency is not new in itself. Aerospace Corp., working for the Air Force, Intercom working for the Defense Communications agency and Bellcom and the General Electric *Apollo* Support Operations for NASA are all examples of companies that have accepted such clauses. Most of these, however, are special children of the parent organizations, specially created to perform the specific job. Hardware exclusion, as a rule, does not apply to other members of the same corporate family.

In the contract negotiated with STL, however, the hardware-exclusion clause extends not only to the actual group doing the ASW work but to the parent company, its affiliates and divisions. Thus, no unit of TRW will be able to bid on Navy ASW hardware.

This is one of the prime reasons the Navy decided to negotiate the contract with STL—their willingness to at least consider such a clause. But another and equally important reason is that STL has the people available immediately to do the Navy's job. Most of the other companies expressing an interest, it is understood, would have had to go out and hire engineers to fullfill the ASW needs.

● **Early systems integration**—A recurrent theme of Navy ASW officials has been the need for earlier and more effective integration of ASW subsystems—sonars, data processors combat intelligence center equipment, fire-control systems and weapons—before they all meet for the first time "on the dock" and must be married to a ship.

This is one of the prime reasons for the centralization of ASW hardware development and production under Adm. Karaberis. It will be the first problem facing the STL group—the evaluation and recommendation of more effective integration of existing equipment.

From this, however, should spring a methodology that could be extended back into the development cycle to insure that systems integration is effected throughout the development cycle of any particluar subsystem.

This integration, it is hoped, could lead to the more effective analysis of what is required in an ASW system and the elimination of unneeded components and test equipment. Finally, the capstone of the systems integration and developmental test support effort is expected to be more reliable equipment having a significantly higher percentage of working time. ■

Phoenix Overrun?

PROJECTIONS of the expenditure rate on *Phoenix* air-to-air missile development show that the system will exceed its 1965 budget by more than $25 million, which may force a stretchout of the program to keep within the overall dollar ceiling.

Roughly half the $25 million will be recouped by reprogramming funds from other programs, Navy officials say. Hughes Aircraft Co. is developing the missile and guidance electronics under a cost-plus-fixed-fee contract.

Navy officials do not consider the $25 million an "overrun" because they feel they will not exceed the total amount for development.

Phoenix is being developed as armament for the Navy F-111B tactical fighter-bomber. Each F-111B will be able to carry six missiles—mounted on hard points below the fixed portion of the aircraft's wing.

The air-to-air missile is understood to be the pacing item in F-111 development. An advanced version of the *AIM-47A* (*Falcon*) and the ASG-18 missile and fire-control system used on the YF-12A, *Phoenix* consists of the missile and the AWG-9/AMCS weapons targeting and fire-control subsystems.

$20 million reprogrammed . . .

Pershing Firing Rate Being Boosted

Procurement of additional missiles and launchers will cut battalion's reloading time, eliminate firing site assembly

by James Trainor

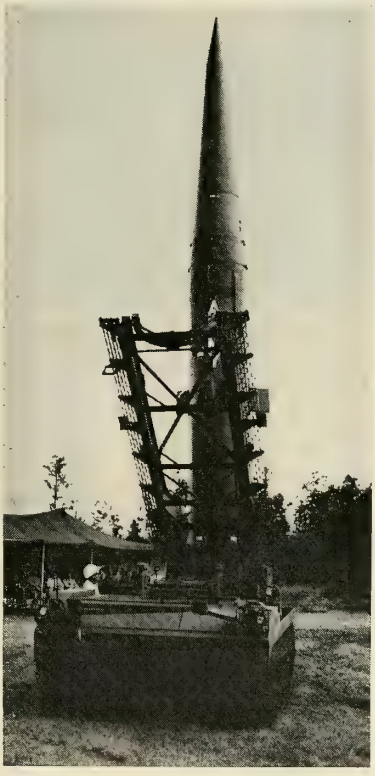
RATE OF FIRE for the Army's *Pershing* missile is being increased through a relatively simple expedient—a change in the logistic support concept for the system.

An analysis by Army and Defense planners has shown that the most time-consuming portion of the firing cycle is reloading the missile launcher after the first round has been fired.

This bottleneck is being eliminated by procurement of additional launchers and missiles that can be added to the basic load of the *Pershing* battalion. Thus, fully assembled missiles on their transporter-erector-launchers will be delivered to the firing battery after the expenditure of a missile. Eliminated by this method is the requirement to assemble missile sections on the launcher at the firing site, with its consequent loss in reaction time.

The latest step in implementing this plan was taken this week with the announcement of a $9.3-million contract award to the Martin Co. for production of *Pershing* missiles. These missiles, the release said, "will be used to strengthen present and planned *Pershing* battalions in the Army." Reprogramming of $20 million in Fiscal 1964 funds for the procurement of additional launchers and associated equipment kicked off the program earlier this year.

● **Taking the lead out**—Under the present tactical concepts for the *Pershing*, the missile battalion is divided into four firing batteries, a headquarters battery and a service battery. Within each firing battery, there is a firing platoon with a one-launcher firing section and an ammunition section. Within the service battery there are organic Engineer, Ordnance and Signal Corps specialists. In the present setup, these specialists pick up the missile from an Army special ammunition point and deliver it in four sections—first stage motor, second stage, guidance unit and warhead—to the firing battery.



PERSHING and launcher. More will be bought to hike missile's rate of fire.

The ammunition section of the battery would then assemble the units on the launcher, with the firing section performing the final checkout and launch. In keeping with the Army's "shoot and scoot" concept of employment, the battery would then displace to another firing sight and receive another missile, which it would then have to assemble before being able to fire.

Defense Secretary Robert S. McNamara recognized this problem when he presented the new concept to Congress. "It takes a relatively short time to fire the first missile but a much longer time to reload the launcher and fire the second," he said. "Therefore, by increasing the number of launchers, we can significantly increase the quick-reaction capability of the *Pershing* force." The reference to increasing the number of launchers, it is now apparent, did not involve beefing up the battalion itself but rather increasing its basic load.

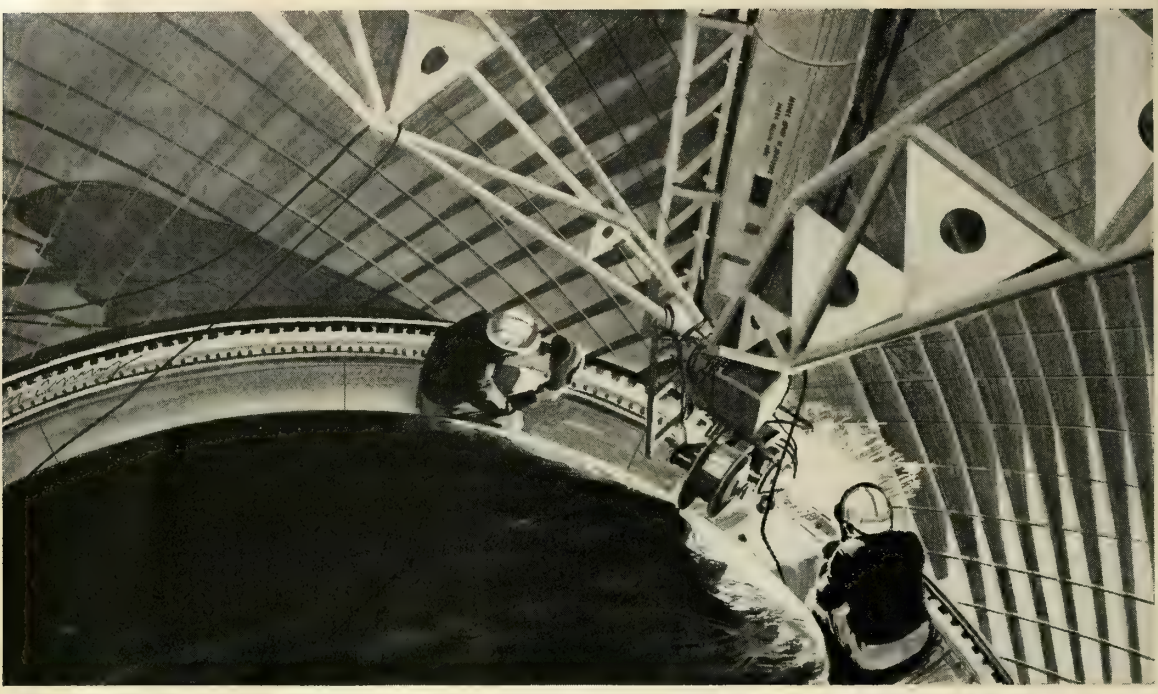
● **New tactical plan**—Under the new concept, the service battery would still pick up the missile in sections from an Army supply point—if for no other reason than to cut down the time lost should one of the four components be found defective, However, missile assembly and launcher loading would take place in the service battery area, with the completely assembled missile being delivered to the firing battery. It would then get a pre-launch checkout and be fired.

Pershing is now being deployed in West Germany with American units and is also being procured by West Germany for its army. The two-stage, solid-propellant, inertially-guided missile has a range of 100-400 n.mi. It is about 35 ft. long and 40 in. in diameter and is carried on a tracked vehicle.

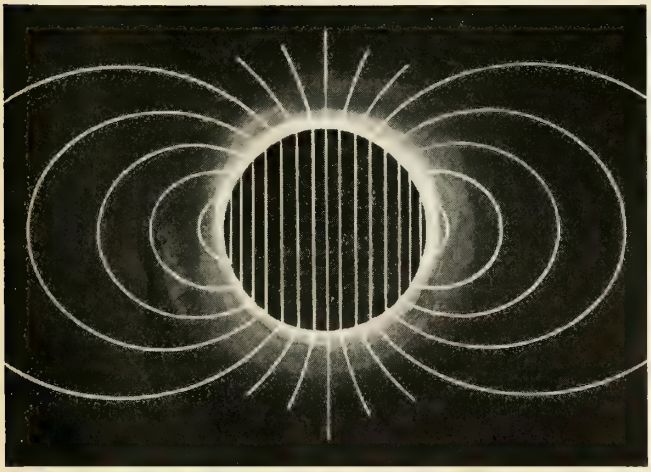
Actually, four tracked vehicles are required to fire the missile—one mounting the erector launcher and missile, another the warhead, a third a checkout hut called the programmer test station and the fourth a tropospheric communications system.

In addition to the Orlando Div. of the Martin Co., the major contractors are: Thiokol for the propulsion; Bendix Eclipse-Pioneer Div., guidance and control; Collins Radio, communications; Universal Match Corp., erector-launcher, and FMC Corp., the M-474 tracked vehicle. Army Materiel Command's Missile Command at Redstone Arsenal, Ala., is responsible for procurement of the system and also sponsored the initial development. ■

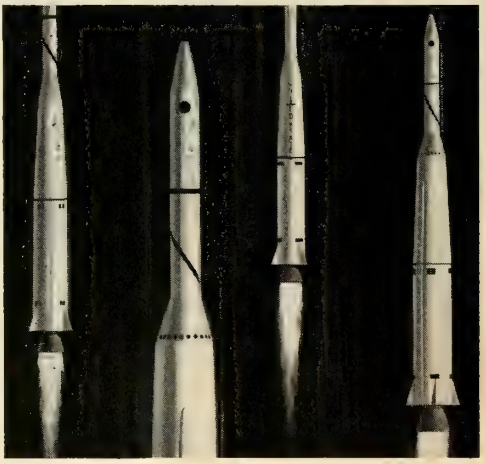
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FINAL ASSEMBLY OF MAMMOTH SPACECRAFT takes place in this huge tooling tower complex at the Douglas Space Systems Center in Huntington Beach, California. Here, provision is made for assembly, hydrostatic testing and checkout of giant space systems. The building includes 4,920 square feet of specially built insulation chambers.



WINDOWS IN THE EARTH'S MAGNETIC FIELD exist at the poles allowing solar and galactic cosmic radiation to penetrate to the vicinity of the Earth. Douglas maintains geophysical observatories in the Northern and Southern polar regions to record the effects of this radiation as it relates to space exploration and basic scientific knowledge. This program is jointly sponsored by Douglas and the National Science Foundation.



DOUGLAS-BUILT DELTAS have launched a majority of all Free World scientific and research satellites. Developed under the direction of the National Aeronautics and Space Administration, this three-stage space booster has achieved 22 consecutive successes. *Delta* is now also available in a new thrust-augmented version (TAD).

DOUGLAS

MISSILE & SPACE SYSTEMS DIVISION

Technical Countdown

ELECTRONICS

Northrop Investigating Vacuum-UV Effects

Experiments to determine what solid materials are transparent to vacuum ultraviolet radiation are being conducted by Northrop Space Laboratories. Vacuum-UV, occupying the range between X-rays and near-UV in the electromagnetic spectrum, is a solar emission always absorbed by the Earth's atmosphere before reaching the surface. Studies of the band from 100 to 2,000 Angstroms with transmittance and reflectance characteristics of materials will benefit solid-state physicists. Materials that eject photoelectrons when irradiated by vacuum-UV will be sought for use as possible sensors in spacecraft. Similarly, irradiated gases will also be studied, since a variety of reactions might open up a new avenue for analysis of planetary atmospheres or vacuums.

Helicopter Platform Powered by Microwave

The transmission of electrical power via microwave has been effectively demonstrated by Raytheon recently for Air Force officials at Burlington, Mass. The rotor-blade motor of a small, tethered, unmanned, helicopter-like platform was powered from a ground-transmitted RF beam whose energy was collected by a diode-rectifying antenna array and converted to 5 kw of power. The demonstration vehicle climbed to about 50 ft. Also shown was an Amplitron tube, developed by Raytheon under an AF contract, that could be employed to generate nearly 100 times as much power from microwave energy at 70% efficiency.

X-Band Planetary-radar Maser Developed

An X-band maser amplifier has been developed for the 30-ft. steerable antenna at the DSIF Venus site at Goldstone, Calif. Intended for the lunar radar project and for planetary experiments involving digital phase modulation, the 8,448-mc radar will now use a nine-cavity maser amplifier mounted in a dewar. Transmitter components used in previous X-band projects are now being modified for high-power use.

HUMAN FACTORS

Voice-Directed Maneuvering Pack Suggested

A human factors engineer in the Space and Armament Systems Section of Honeywell's Aeronautical Division in Minneapolis reports that a maneuvering unit consisting of rocket packs strapped to astronauts' backs could best be operated by voice command. Only 10 words would be needed, he claims. These would be directed by microphone to a command system in the backpack, actuating reaction jets. The system would have the advantage of leaving the astronauts' hands completely free to do manual operations.

PROPULSION

Nine-Pulse Solid Fired By Lockheed

Nine propellant wafers in a pulse motor have been fired on command in a series of two, three and four bursts at Lockheed Propulsion Co.'s Redlands, Calif., facility. The rapid-fire static test was conducted under a contract with the Rocket Propulsion Lab, Edwards AFB. Expected pulse-to-pulse reproducibility was attained and the structural and ballistics performance of the motor was as predicted. Such pulse-operated solid motors are an approach to space applications requiring stop-restart-stop ability for the intermittent repositioning of satellites.

Aerojet To Produce Commercial Rockets

A facility is being readied at Aerojet-General/Sacramento for production of small 350-lb.-thrust rocket engines recently certified by the FAA for emergency standby power on small civil aircraft. Developed by Aerojet-General's solid propulsion engineers, the 12NS-350 engine is 6 in. across and 28 in. long. It weighs 46.5 lbs. and has a burning time of 12 seconds. The engine has been installed on more than 120 aircraft to date.

ADVANCED MATERIALS

Friction Joins Aluminum to Stainless Steel

Transition joints between aluminum and stainless steel structures are being made through a new friction-welding process perfected by the Friction Welding Div. of AMF in Shreveport, La. The process fusion joins dissimilar metals using the heat generated by friction created when a rotating piece is pressed against a stationary member. The Al-stainless joints have been tested in cryogenic rocket applications with good results. Welding tests have proven the integrity of the weld and the AMF division has subjected the parts to numerous environmental tests.

Electro-coating Plates 65-in. Mirror

A 65-in. mirror destined for the Douglas Space System Center Solar Simulator just finished the plating phase at Electro-Coating's Industrial Hard Chrome Plating Div. A patented electroless nickel process was used. The aluminum mirror was coated with highly polished nickel and then aluminized in a vacuum. The mirror will be used to collimate simulated solar radiation for tests on materials and components at different simulated altitudes.

NASA/Lewis Gets Uranium Foil

The Y-12 plant at Oak Ridge, Tenn., has fabricated sheets of uranium foil 10 mils thick for shipment to NASA's Lewis Research Center at Cleveland. The total amount of depleted uranium involved was 220 lbs. The uranium was initially cast as a billet and then rolled and sheared into five sheets. These were reduced to 20-mil thicknesses on a Sendzimir mill and the final dimension was reached through tension-rolling. Union Carbide Corp. operates the Oak Ridge Y-12 plant for the Atomic Energy Commission.

Chemical Saw for Metal Crystal Cutting

A British firm slices deformation-free samples of metal crystals using a polyester thread soaked in a suitable solvent. The reaction products are removed and even soft metals can be sliced with crystal integrity intact. The chemical saw in a development of Mettallurgical Services, Reliant Works, Betchworth, Surrey, England.



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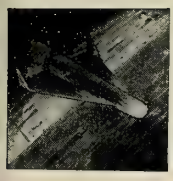
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ITT

ASTROLOG

Current status of U. S. missile and space programs



Satellites and Spacecraft

ADVANCED ORBITING SOLAR OBSERVATORY (NASA)—CONTRACTORS: Republic, prime. DESCRIPTION: 1,200-lb. spacecraft to make detailed measurements of Sun's solar radiation; greater pointing accuracy than OSO; launch vehicle, THRUST AUGMENTED THOR-AGENA. STATUS: Component development; planned to dovetail with OSO, with the first spacecraft launched in 1968.

ADVANCED TECHNOLOGICAL SATELLITE (NASA)—CONTRACTORS: Hughes, prime. DESCRIPTION: Five-satellite program to test communication and meteorological equipment at medium and synchronous orbit; test bed for gravity gradient experiments; weight, 650 lbs.; launch vehicle, ATLAS-AGENA. STATUS: Development; first flight scheduled for 1966.

APOLLO (NASA)—CONTRACTORS: North American, command & service modules, systems integration; Grumman, Lunar Excursion Module (LEM); MIT, guidance development; Collins Radio, telecommunications; Honeywell, stabilization & control; AiResearch, environmental control; Northrop-Ventura, parachute recovery; Lockheed Propulsion Co., escape tower rocket; Marquardt, reaction controls; IBM, realtime computer complex; Westinghouse, power conversion equipment. Lunar Excursion Module, prime, Grumman; descent engine, Rocketdyne & TRW Space Technology Laboratories; ascent engine, Bell Aerosystems; environmental control, Hamilton Standard; reaction control thruster, Marquardt; guidance, MIT; radar & communications instruments, RCA; TMC, telemetry, Radiation Inc.; fuel cell, Pratt & Whitney; external visual display, Forand Optical. DESCRIPTION: Three-man spacecraft for Earth-orbital, lunar-orbital and lunar-landing missions. Boosters: SATURN I and SATURN IB for Earth orbits; SATURN V for lunar rendezvous and landing missions; 3-modular spacecraft: Command Module weight, five tons; Service Module, 23 tons, Lunar Excursion Module, 12.75 tons; total weight, 85,000 lbs. STATUS: First of a series of unmanned orbital tests began with a boilerplate model launch on SA-7, Sept. 18; lunar orbits scheduled 1968; lunar landing by 1970; first manned orbital flight due last half of 1966.

ASSET (Air Force)—CONTRACTORS: McDonnell Aircraft Corp., prime; Honeywell, gyros; Bell Labs, guidance. DESCRIPTION: Aerothermodynamic/elastic Structural Systems Environmental Tests for various materials combinations during re-entry; delta-shaped re-entry vehicle; two versions planned weighing 1,100 lbs. (4 vehicles) and 1,200 lbs. (2); length, 68.7 in.; span, 58.9 in. STATUS: Development. One AMR shot in September, 1963, successful although vehicle not recovered; second vehicle successfully launched and recovered, July 22; third launched Oct. 28; three shots remain in program (see START).

BIOS (NASA)—CONTRACTORS: GE, prime. DESCRIPTION: 1,000-lb. satellites to test effects of space environment on plants, animals (primates) and other biological specimens; launch vehicle, THRUST-AUGMENTED DELTA. STATUS: Six flight models to be built; first flight in December, 1965; others to follow at three-month intervals; first experiments selected in February.

COMSAT CORP. SATELLITE PROGRAM—CONTRACTORS: Studies being performed by Hughes, TRW with ITT, and AT&T and RCA as joint contractors. STUDIES: AT&T/RCA, 18 satellites, medium-altitude random orbit; STL/ITT, 12 satellites, medium altitude, controlled orbit using gravity gradient stabilization; Hughes 2nd-generation synchronous orbit system. STATUS: First satellites to be in orbit by mid-1966, with entire system operational by mid-1967.

DISCOVERER (Air Force Program 622A)—CONTRACTORS: Lockheed, prime; GE, re-entry vehicle. DESCRIPTION: THOR-AGENA and ATLAS-AGENA launchings of stabilized satellites; main purpose is to test techniques and components for military space systems. STATUS: All data on program classified as part of DOD information policy; however, indications are that program has been cut back or ended as more economical vehicles have come into use.

EARLY BIRD (ComSat Corp.)—CONTRACTORS: Hughes, prime. DESCRIPTION: Experimental modified syncom to be placed in 22,300-mi. stationary orbit and provide 240 two-way telephone channels between U.S. and Europe or simultaneous transmission of 22 or more telegraph messages; booster, THRUST-AUGMENTED DELTA. STATUS: Development; contract calls for delivery of first satellite by April, 1965; launch scheduled for mid-1965.

ECHO (NASA)—CONTRACTORS: Langley Research Center, prime. DESCRIPTION: ECHO I, 135-ft. inflatable sphere in 700- to 805-mi. orbit; passive communication satellite; booster, THOR for ballistic tests; THOR-AGENA for orbital. STATUS: Program complete; ECHO I in orbit since Aug. 12, 1960; two ballistic shots in 1962 unsuccessful; ECHO II launched from Vandenberg Jan. 27; U.S.-USSR conducting series of cooperative experiments using ECHO.

GEMINI (NASA)—CONTRACTORS: McDonnell, prime; Rocketdyne, spacecraft propulsion; General Electric, fuel cell; IBM, guidance system integration and computer; Honeywell, guidance; Westinghouse, rendezvous radar; AiResearch, environment. DESCRIPTION: Bigger and heavier MERCURY-type capsule to carry two men for up to two weeks; TITAN II to be used as booster; ATLAS-launched AGENA will be used for rendezvous missions; 15 spacecraft will be produced. STATUS: Development; 12 flights planned; will be used to determine feasibility of rendezvous for lunar mission and long-duration manned flight; first unmanned flight, April, 1964, successful; second postponed to 4th quarter 1964 after lightning damaged GT-2 in August; first manned flight, 1st qtr. 1965; manned and rendezvous flights, 1965-67; AF participating in program, and will modify GEMINI capsules for MANNED ORBITING LABORATORY.

GEOS (NASA)—CONTRACTORS: Applied Physics Laboratory, prime. DESCRIPTION: 350-lb. geodetic satellite (similar to ANNA) to carry flashing-light beacons, electronic beacons and optical and radar reflectors; launch vehicle, THRUST-AUGMENTED DELTA; 700-900-mi. orbit at a 59-degree inclination. STATUS: First flight planned in third quarter 1965.

HYPERSONIC RESEARCH VEHICLE (AF, NASA)—CONTRACTORS: None announced. DESCRIPTION: Manned, hypersonic spacecraft capable of Earth-to-orbit-and-return; turbofan, Mach 0-3; ramjet, Mach 3-8 or 10 (oxygen collected and liquefied during this cycle); Mach 8-10 orbital speeds, LH_2-LOX rocket. STATUS: Joint NASA-AF research program approved; NASA funding $2.5 million in FY '65; AF has advanced technology program in six pertinent areas (mostly engine developments) in FY '65.

ICBM ALARM (Formerly MIDAS) (Air Force Program 239A)—CONTRACTORS: Lockheed, prime; Aerojet, IR detector system. DESCRIPTION: Early-warning random orbit satellite; detect ICBM launchings by IR; two flights conducted in 1963 detected solid and liquid missile launches; satellites are launched piggy-back on various AF boosters. STATUS: Development; no decision on deployment; reportedly competing with over-the-horizon radar.

INTERPLANETARY MONITORING PLATFORM (NASA)—CONTRACTORS: Goddard Space Flight Center, prime; Martin Co. developing nuclear power unit. DESCRIPTION: 140-lb. satellite launched into cislunar-space orbit with an apogee of more than 100,000 mi.; will measure radiation and solar flare hazards in advance of Project APOLLO; launched by DELTA booster from AMR. STATUS: IMP-I launched in December, 1963; IMP-II launched Oct. 3; 3 more satellites are planned, two to be placed in lunar orbit; later flights will use a nuclear power unit as replacement for solar cells; Designation, IMP-A is EXPLORER XVIII.

ISIS (Canada, U.S.)—CONTRACTORS: Canadian Defense Research Board, satellite; NASA, launch vehicle. DESCRIPTION: Three-satellite follow-on program to ALOUETTE to continue ionospheric studies. STATUS: Design of ISIS A to begin this year with launch in 1967; B and C to be launched in 1968, 1969.

LUNAR LOGISTICS SYSTEM (NASA)—CONTRACTOR: Studies have been conducted by Grumman, TRW/STL and Northrop. DESCRIPTION: Spacecraft to carry support payloads to the Moon. Two designs under study—LEM truck with 7,000-lb. payload and logistics spacecraft with 25,000 to 30,000 lb. payload; booster: SATURN V. STATUS: Program definition of the LEM truck planned in FY '66; program would cost about $1 billion.

LUNAR ORBITER PHOTO CRAFT (NASA)—CONTRACTORS: Boeing, prime; RCA, power and communications; Eastman Kodak, cameras; Marquardt, maneuvering engine. DESCRIPTION: 830-lb. spacecraft launched by ATLAS-AGENA will orbit Moon taking pictures of lunar surface; radioactive and geodetic measurements will also be taken. STATUS: Five flights scheduled beginning in mid-1966.

MANNED ORBITING LABORATORY (Air Force)—CONTRACTORS: Aerospace Corp., systems engineering & technical direction; study contracts awarded to Douglas, GE, and Martin on the ORBITING SPACE STATION (OSS); also contracts for studies of selected sub systems. DESCRIPTION: Two-man spacecraft to establish military usefulness of man in space; booster, TITAN III-C; GEMINI-B capsule atop 10-ft.-dia., 20-ft.-long canister lab; total weight about 18,000 lbs.; orbit below 350 mi.; flights of 30 days in shirt-sleeve environment planned. STATUS: Pre-program definition; RFPs expected to be issued in November, 1964; unmanned GEMINI launch early 1966; unmanned canister launch late 1967, manned first half 1968; rendezvous capability possible later.

MARINER (NASA)—CONTRACTORS: Jet Propulsion Laboratory, prime. DESCRIPTION: 570-lb. unmanned spacecraft for early interplanetary missions to vicinity of Mars and Venus; boosted by ATLAS-AGENA. STATUS: First scheduled Venus fly-by, August, 1962, unsuccessful after booster failure; second passed within 21,594 mi. of Venus, Dec. 14; two Mars fly-by missions planned in November, 1964; because of press of maintaining APOLLO schedules, NASA has dropped plans for 1966 Mars shot; agency will concentrate efforts on 7,000-9,000 lb. spacecraft for 1969 window.

MILITARY COMMUNICATIONS SATELLITE (Program 369) (AF, DCA, Army)—CONTRACTORS: Aerospace Corp., systems engineering & technical direction; Philco, prime. DESCRIPTION: Multiple-launch, random, active repeater comsat; 16-24 satellites launched in groups of 6-8 satellites in 19,000 n.mi. polar orbits; weight about 100 lbs.; TITAN-III-C booster. STATUS: Full-scale development as an "interim" system which is to be in operation in 1966.

NATIONAL ORBITING SPACE STATION (NASA, AF)—CONTRACTORS: Many studies awarded. DESCRIPTION: Manned space station with orbital lifetime of one to five years for testing components and techniques in the space environment; weight ranges under study vary from 15,000-20,000 up to 200,000 lbs. STATUS: Decision not expected for one to four years; APOLLO-X, AF MANNED ORBITING LABORATORY, MANNED ORBITING RESEARCH LABORATORY and LARGE ORBITING RESEARCH LABORATORY being considered; program definition of APOLLO-X expected in FY '66; longer-life stations delayed until 1970's.

NIMBUS (NASA)—CONTRACTORS: Goddard Space Flight Center, prime; GE, integration and testing; RCA, videcon cameras. DESCRIPTION: 830-lb. second-generation weather satellite; Earth-stabilized polar orbiting; TV cameras and IR scanners in payload; THOR-AGENA B booster. STATUS: First launching successful August 28; picture & IR quality good in spite of satellite's elliptical orbit; satellite quit transmitting Sept. 23; second scheduled for launch within a year; two R&D satellites to be funded in FY '65; uses Automatic Picture Transmission system.

NUCLEAR DETECTION SATELLITES (Formerly Vela) (ARPA)—CONTRACTORS: TRW Space Technology Laboratories, prime; Los Alamos Scientific Lab/Aerospace Corp., payload. DESCRIPTION: 20-sided, 485-lb. satellite for detection of nuclear explosions in space; 50,000-mi. orbit; booster, ATLAS-AGENA; launched in pairs. STATUS: First pair successfully launched in October, 1963; second pair successfully launched July 17, 1964; three pairs remain.

OAO (NASA)—CONTRACTORS: Grumman, prime; Westinghouse, ground station, components; GE, stabilization and control; Kollsman, star trackers; IBM, data processor and storage; Hughes and Avco, communications equipment. DESCRIPTION: 3,600-lb. orbiting atronomical satellite to study ultraviolet spectrum from approximately 1,200 Å to 4,000 Å; four major experiments selected; one piggyback; booster, ATLAS-AGENA D. STATUS: Three flights beginning in late 1965.

OGO (NASA)—CONTRACTORS: TRW Space Technology Laboratories, prime; DESCRIPTION: 1,000-lb. satellite with instruments for geophysical measurements; polar (POGO) and eccentric (EGO) shots planned; can carry more than 20 experiments; ATLAS-AGENA B, THRUST-AUGMENTED THOR boosters. STATUS: First launch on Sept. 4 partially successful; 16 of 20 experiments working; next launch (a POGO) early 1965.

OSO (NASA)—CONTRACTORS: Ball Brothers, prime. DESCRIPTION: OSO 1,458-lb. orbiting solar observatory; OSO II, 535-lbs.; DELTA booster; S-16 early version; S-17 and S-57 advanced versions. STATUS: First flight Mar. 7, 1962, highly successful; first flight for S-17 planned for second quarter 1964 delayed until 1965; five more flights planned.

PEGASUS (NASA)—CONTRACTORS: Fairchild Hiller, prime. DESCRIPTION: 3,400-lb. meteoroid-detection satellite employing two 50 x 15-ft. extendable detector wings; Earth orbit 300 to 800 mi.; booster, SATURN I. STATUS: Development; will measure size, energy and frequency of meteoroids to evaluate hazards of impact with manned spacecraft; first launch scheduled for third quarter 1964; formerly known as MDS; two more satellites will be launched as part of SATURN I development program.

PIONEER (NASA)—CONTRACTORS: TRW Space Technology Laboratories. DESCRIPTION: 140-lb. spin-stabilized solar probe; augmented DELTA launch vehicle; cylindrical; covered with 10,000 solar cells; four outrigger booms for stabilization; five experiments, 60 to 90-million-mi. communication capability. STATUS: Seven launches in program; early 1965 launch schedule set; orbits range from 0.8 to 1.2 au for 6-mo. lifetime; ADVANCED PIONEER under study.

RADIO ASTRONOMY OBSERVATORY (NASA)—CONTRACTORS: Goddard, prime (although industry may be asked to build RAO). DESCRIPTION: 270-lb. satellite which will have four 750-ft. extendable antennas to pinpoint radio emissions in space. STATUS: Program approval and funding expected in FY '66 budget, with first launch by a THRUST AUGMENTED DELTA in 1967.

RANGER (NASA)—CONTRACTORS: JPL, prime; Hercules, retro-rocket; Northrop, support contractor; RCA, TV system. DESCRIPTION: Before impact, TV cameras take pictures of lunar surface; ATLAS-AGENA B booster. STATUS: RANGER VI launch Jan. 30; TV system failed; RANGER VII launched July 28 and impacted Moon after transmitting 4,316 pictures back to Earth; RANGER VIII scheduled for Jan., 1965, with IX two months later; this will complete RANGER program.

RELAY (NASA)—CONTRACTORS: TRW Space Technology Laboratories, project coordination and systems planning; RCA, prime. DESCRIPTION: 172-lb. spin-stabilized wideband 800 to 4,600-mi.-orbit active repeater experimental communications satellite; DELTA booster. STATUS: Britain, France, Brazil and Germany building ground stations; first launch, Dec. 13, 1962; RELAY II launched Jan. 21, 1964; program completed.

SAMOS (Air Force Program 720A)—CONTRACTORS: Lockheed, prime; photo intelligence equipment, Eastman Kodak; capsules, GE; parachute and guidance recovery equipment, AVCO and Northrop Ventura. DESCRIPTION: Reconnaissance satellite; formerly SENTRY; R&D model weighs 4,100 lbs. with E-5 capsule (3,000 lbs. with E-6); ATLAS-AGENA booster; 100-300-mi. circular polar orbit. STATUS: Operational; advanced SAMOS under development; FERRET version used for electronic intelligence and communications eavesdropping.

SATAR (Air Force)—CONTRACTORS: General Dynamics, prime. DESCRIPTION: 300-lb. scientific satellite pod mounted on side of ATLAS booster; length, 55 in.; diameter 27 in.; 200-lb payload; orbits vary from 500 to 2,000 n. mi.; as re-entry vehicle, gains speeds up to 30,000 fps; guidance, strap-down system with three orthogonally-mounted gyros; unstabilized when in orbit. STATUS: Development; seven vehicles being built under present contract; pods of SATAR type have been flown on 44 missions.

SATELLITE INSPECTOR (Air Force PROGRAM 706)—CONTRACTORS: None. DESCRIPTION: Satellite inspection system consisting of a spacecraft capable of co-orbital inspection of non-cooperative satellites. STATUS: Re-oriented from unmanned vehicle to manned satellite using GEMINI; Conceptual preliminary design studies under way; early GEMINI flights expected to provide important inputs; $2 million in FY '65 budget.

SECOR (Army)—CONTRACTORS: ITT Labs, prime; Cubic Corp., transponder. DESCRIPTION: 40-lb. geodetic satellite; rectilinear, measuring 9 x 11 x 14 in.; can be carried piggyback on a variety of boosters; frequency, 162-324 mc for geodetic measurements; 54-216 mc for refraction studies. STATUS: Operational; third launch took place early this year on AF secret satellite; an expanded program at altitudes of 1,800 mi. is being considered.

SERT I (NASA)—CONTRACTORS: RCA, prime. DESCRIPTION: Spinning ballistic test vehicle carrying two electric-propulsion engines for environmental tests. STATUS: First flight July 20 from Wallops Island, Va., carried a Lewis electron bombardment engine and a Hughes contact ionization engine; the Lewis engine worked well while Hughes engine produced no thrust; follow-on flights cancelled since SERT I proved neutralization of an ion beam in space.

START (Air Force)—CONTRACTORS: Award in only one of an expected 10-14 areas has been announced: Martin Co. for work on a vehicle related to the in-house SLV-5. DESCRIPTION: An experimental program, much broader than ASSET, to explore the materials, structures, flight regimes and other areas related to glide atmospheric entry. STATUS: Program package is still being assembled and is not expected to be ready before the end of 1964.

SURVEYOR (NASA)—CONTRACTORS: Hughes, prime; Martin, SNAP device. DESCRIPTION: 2,100-lb. spacecraft for soft-landing 100-300 lbs. of instruments on Moon; nine 2,500-lb. spacecraft are also planned; ATLAS-CENTAUR booster; SNAP nuclear generator optional. STATUS: First Moon flights late 1965; five soft-landing vehicles planned in Block I series.

SYNCOM (NASA)—CONTRACTORS: Hughes, prime. DESCRIPTION: 24-hr. orbit instantaneous narrow band, active repeater communications satellite; 28-in. in dia. and weighs about 63 lbs.; DELTA booster; capable of accommodating one full duplex radio telephone channel. STATUS: First launch failed, Feb. 14, 1963; satellite believed to be in orbit but contact lost; SYNCOM II launched July 26, 1963, completely successful; third launch Aug. 19 successful; satellite, positioned in stationary orbit over Pacific, relayed 1964 Olympic Games to U.S. from Japan; program now complete.

SMS (Synchronous Meteorological Satellite) (NASA)—CONTRACTORS: Republic, RCA Astro-Electronics; Hughes, study contracts. DESCRIPTION: 24-hr. weather satellite, Earth-stabilized; TV cameras with variable focus; may use SNAP-50 for power; booster may be ATLAS-AGENA or -CENTAUR. STATUS: Studies to continue; development funds not included in FY '65 budget; ATS expected to provide major inputs to the program.

TELSTAR (AT&T, NASA)—CONTRACTORS: Bell Telephone Laboratories, management for AT&T. DESCRIPTION: 170-lb. active repeater experimental industry communication satellite; DELTA booster. STATUS: Development; first launch July 10, 1962, highly successful; second launch May 7, 1963, also successful; program now complete.

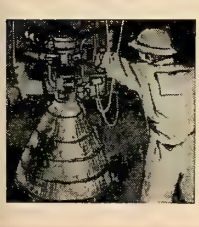
TIROS (NASA), Weather Bureau)—CONTRACTORS: RCA, prime. DESCRIPTION: 285-lb. meteorological satellite; TV pictures of cloud cover; IR sensors to gather heat balance data; one TIROS to be tested for effectiveness in highly elliptical orbit (300-3,000 mi.). STATUS: R&D; eight satellties launched; all successful; five more launches planned with TIROS wheel configuration (Earth stabilized) to serve as an interim National Operational System.

TRANSIT (NAVY)—CONTRACTORS: Applied Physics Laboratory, prime; Martin, SNAP device; Westinghouse, shipboard satellite signal receivers. DESCRIPTION: Navigational satellite; R&D model over 250 lbs.; operational, 50 to 100 lbs.; operational system; four satellites in random, near-circular 600-mi. orbits; SNAP nuclear generator; ABLESTAR booster. STATUS: Operational system established for use by POLARIS subs and surface ships; two nuclear-powered (SNAP-9A) satellites launched in 1963; NASA exploring feasibility of commercial system.

TRS (Air Force)—CONTRACTOR: TRW/STL. DESCRIPTION: 3-lb. scientific satellite to measure radiation; four-sided, measuring 9 in. on a side. STATUS: Operational; first launched piggyback on DOD payload Oct. 17, 1963.

VOYAGER (NASA)—CONTRACTORS: Study contracts, Avco and GE. DESCRIPTION: Unmanned MARINER follow-on spacecraft to orbit Mars and VENUS and to eject a capsule to the surface. STATUS: Development funds included in FY '66 budget; launches in 1971-73 period; spacecraft to be launched by SATURN IB/CENTAUR, TITAN III or SATURN V.

X-15 (NASA, AF, NAVY)—CONTRACTORS: North American, prime; Thiokol, propulsion; Sperry Gyroscope, inertial flight data system; Honeywell, adaptive flight control electronics. DESCRIPTION: Manned rocket plane capable of 4,000-mph-plus flight at edge of space; single rocket engine develops 57,000 lbs. thrust. STATUS: Powered flights in progress; unofficial records set—altitude 354,200 ft. and speed 4,104 mph; hypersonic propulsion research program should run through 1968; more than 100 flights have been made; ramjet (X-15A2) flights scheduled for 1968.



Space Vehicles

ABLESTAR (Air Force)—CONTRACTORS: Space General, prime; Aerojet, propulsion; Space General/Bell Telephone, guidance. DESCRIPTION: 2,000-lb. upper stage; 9.5 ft. long; 55 in. dia.; radio command guidance; propellants, UDMH/IRFNA; restart capability. STATUS: Used in TRANSIT and other military programs; THOR booster.

ATLAS-AGENA D (Air Force)—CONTRACTORS: General Dynamics/Astronautics, (ATLAS); Lockheed (AGENA); TRW/STL, AGENA B; Honeywell, inertial reference. DESCRIPTION: 275,000-lb. booster; payload capability, 5,000 lbs., in 345-mi. orbit, 750 lbs. to escape, length, 102 ft.; base diameter, 10 ft.; liquid propulsion; modified Atlas D with 360,000-lb. thrust; Agena B with 15,000-lb. thrust; restart capability. STATUS: Operational; used in RANGER, DISCOVERER, MILITARY COMSAT, MARINER, LUNAR ORBITER, OAO, SAMOS and other programs.

AGENA D (Air Force)—CONTRACTORS: Lockheed, prime; Honeywell, guidance; Bell, propulsion. DESCRIPTION: 1,700-lb. upper stage; 25 ft. long; 5 ft. dia.; all-inertial guidance; propellants, UDMH/IRFNA; multiple re-start capability; ATLAS, THOR and THOR-augmented boosters. STATUS: Used in DISCOVER, SAMOS and other military programs as well as a variety of NASA programs; e.g., MARINER, RANGER, OAO and OGO.

CENTAUR (NASA)—CONTRACTORS: Lewis, program management; General Dynamics/Astronautics, prime; Pratt & Whitney, propulsion; Honeywell, guidance. DESCRIPTION: High-energy upper stage using a pair of RL-10 LOX/liquid hydrogen engines; 30,000 lbs. total thrust; 30 ft. long; 10 ft. dia.; ATLAS D booster; capable of orbiting 8,500 lbs.; 2,300 lbs. to escape; 1,300 lbs. on planetary flights. STATUS: Development; first test flight failed; second launch Nov. 27, 1963, highly successful; third, June 20, 1964, partially successful; fourth flight set for November, 1964 and seven in 1965 when the vehicle is to become operational.

DELTA (NASA)—CONTRACTORS: Douglas, prime; Bell Telephone Labs, guidance; Rocketdyne/Aerojet/Allegany Ballistics Laboratory, propulsion. DESCRIPTION: Successor to THOR-ABLE; upper stage guidance; three-stage vehicle; 800-lb. payload capability in 100-mi. orbit; THRUST-AUGMENTED DELTA payload capability 1,500 plus lbs. in 100-mi. orbit; THOR missile comprises first stage. STATUS: launch vehicle for TIROS, EXPLORER, OSO, BIOS, ECHO; TAD used for SYNCOM & PIONEER; 26 previously on order augmented by AF order for 21 more for NASA; THRUST-AUGMENTED DELTA with three solid motor strap-ons also being used.

LITTLE JOE II (NASA)—CONTRACTORS: General Dynamics/Convair, prime. DESCRIPTION: Solid-propelled vehicle with 800,000-lb. thrust; launch vehicles for APOLLO suborbital flights. STATUS: Two launches Aug. 28, 1963, and May 13, 1964, successful; six vehicles ordered thus far; third launch scheduled for Dec., 1964.

POST-SATURN V LAUNCH VEHICLE (formerly NOVA) (NASA)—CONTRACTORS: Studies. DESCRIPTION: Capability of NOVA under study; no firm concept but should offer significant improvement over C-5 (20-30 million-lb. first-stage thrust large solid motors, and nuclear upper stage under consideration). STATUS: Study to determine characteristics; operational target date post-1970.

PROJECT FIRE (NASA)—CONTRACTORS: Republic, re-entry package; Ling-Temco-Vought, velocity package; General Dynamics/Astronautics, launch vehicle and systems integration. DESCRIPTION: Re-entry probe to measure environmental heating at lunar return speeds (25,000 mph); launch vehicle, ATLAS D plus Antares II A-5 (re-entry booster). STATUS: R&D: first flight April, 1964, successful; second flight scheduled for mid-1965.

PROJECT SCANNER (NASA)—CONTRACTORS: Honeywell, fabrication and integration; Baird-Atomic; star-mapper telescope; Santa Barbara Research Center, dual radiometers. DESCRIPTION: Unmanned scientific satellite to measure natural radiation gradients of Earth's horizon to determine utility of spacecraft horizon sensors. STATUS: Flights to begin in 1965.

ROVER (NASA, AEC)—CONTRACTORS: Los Alamos Scientific Labs, ROVER prime; Aerojet, NERVA prime; Westinghouse, propulsion. DESCRIPTION: First nuclear rocket; tests of Kiwi, prototype of NERVA engine, under way. STATUS: Kiwi tests completed this year; NERVA tests highly successful; full systems tests of engine now set for fall, 1965—12 months ahead of schedule; development of Phoebus reactor initiated; no flight test program funded at present.

SATURN I (NASA)—CONTRACTORS: Systems engineering, assembly and guidance, Marshall Center; S-1 stage, Chrysler Corp.; S-IV, Douglas. DESCRIPTION: Two-stage vehicle for early boilerplate tests of APOLLO and PEGASUS; first stage: eight Rocketdyne H-1 engines; second stage: six Pratt & Whitney RL-10-A3 engines; 22,000 lbs. into 345-mi. orbit. STATUS: Four flight tests of first stage successful; all flights with inert upper stage; first flight with live upper stage successfully launched Jan. 27, putting 37,700 lbs. in low Earth orbit; SA-6 May 28, 1964 and SA-7 Sept. 18, 1964, also successful; three more R&D flights planned to complete development effort.

SATURN I-B (NASA)—CONTRACTORS: Systems engineering, assembly and guidance, Marshall Center; S-1 stage, Chrysler; S-IVB stage, Douglas. DESCRIPTION: S-1, eight H-1 engines; S-IVB, one J-2 engine; payload capability, 28,500 lbs. in 345-mi. orbit. STATUS: Development; first flight in 1966; boost APOLLO spacecraft boilerplate models, including lunar landing vehicle; first manned flight in APOLLO program set for late 1966; advanced version able to orbit 30 tons under consideration.

SATURN V (ADVANCED SATURN) (NASA)—CONTRACTORS: Systems engineering, assembly and guidance, Marshall Center; S-IC, Boeing; S-II, North American; S-IVB, Douglas; F-1, North American; J-2, North American. DESCRIPTION: S-IC, five F-1 engines; S-II, five J-2 engines; S-IVB, J-2 engine; 120-ton payload in 345-mi. orbit; 43 tons to escape velocity; 30 tons for planetary missions. STATUS: R&D; first flight scheduled for 1967; prime booster for APOLLO missions; will be used to boost orbiting space station.

SCOUT (NASA)—CONTRACTORS: LTV Astronautics, prime; Honeywell, guidance; Aerojet/Thiokol/Allegany Ballistics Laboratory, propulsion. DESCRIPTION: Solid propulsion four-stage satellite launcher; 72 ft. long; 3.3 ft. dia.; 300-lb. payload in 345-mi. orbit; 80 lbs. to escape. STATUS: Operational; used by NASA for EXPLORER and other small payloads; also procured by NASA for Air Force as BLUE SCOUT; NASA has ordered 23 more boosters.

THOR-ABLE STAR (Air Force)—CONTRACTORS: Douglas, prime; Bell Telephone labs, guidance; Rocketdyne, first-stage propulsion; Space/General, second; DESCRIPTION: Two-stage vehicle with 181,900 lbs. total thrust; performance, 900 lbs., in 100-n.-mi. orbit; length, 55.9 ft., diameter, 8 ft., weight, 118,200 lbs., height, 79 ft.; guidance, radio command; STATUS: Operational; used in TRANSIT and other military program.

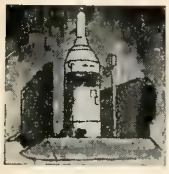
THOR-AGENA D (Air Force and NASA)—CONTRACTORS: no prime; Douglas, THOR frame; Lockheed, AGENA D; Rocketdyne, propulsion. DESCRIPTION: Liquid-propulsion vehicle to put 1,600-lb. payload in 300-mi. orbit; length, 76 ft.; diameter, 8 ft.; launch weight, 123,000 lbs.; 172,000 lbs. thrust; THOR, radio guidance, AGENA, all-inertial. STATUS: Operational; used in AF space program; TELSTAR, Topside Sounder and other NASA programs; NASA has 11 launched scheduled.

THRUST-AUGMENTED DELTA (NASA)—CONTRACTOR: Douglas, prime; Thiokol, solid propulsion. DESCRIPTION: DELTA launch vehicle with three strap-on solids; performance, 1,000 lbs. to Earth orbit; 150 lbs. to escape; propulsion, three XM-33 solid motors producing 55,000 lbs. thrust each. STATUS: Development; to be used for BIOSATELLITE, PIONEER, SYNCOM, TIROS and COMSAT programs; initial flight in 1964.

THRUST-AUGMENTED THOR (Air Force/NASA)—CONTRACTORS: no prime; Rocketdyne, and Thiokol, propulsion. DESCRIPTION: THOR-AGENA with 3 strap-on solids; THOR liquid propulsion, 172,000 lbs. of thrust; each strap-on, 55,000 lbs. thrust; performance, 2,500 lbs. in 100-n.mi. orbit. STATUS: Operational; used for NIMBUS and POGO and others too heavy for THOR, but not heavy enough for ATLAS.

TITAN II (GLV) (NASA)—CONTRACTOR: Aerospace Corp., systems engineering & technical direction; Martin, prime. DESCRIPTION: Manned space booster; Essentially Titan II with addition of redundant electrical power and flight control systems; malfunction detection system and radio command guidance. STATUS: Development; GT-2 (unmanned version) to be launched late this year.

TITAN III (Air Force Program 624A)—CONTRACTORS: Aerospace Corp., systems engineering & technical direction; Martin, systems integration; United Technology, large solid boosters; Martin, TITAN II vehicle; Aerojet, liquid engines; Martin, standardized upper stage; AC Spark Plug, guidance. DESCRIPTION: Quick-reaction vehicle for military space missions; will be used to boost MOL/GEMINI B; Zero stage, two 120-in. solid motors; first and second stages, TITAN II (storable propellants); third-stage standardized vehicle to be developed; modified TITAN II guidance; payload, 25,000 lbs. in 100 n.mi. orbit, 2,100 to 22,300-mi. orbit; 5,000 to escape. STATUS: Development; first flight Sept. 1 (T-IIIA) achieved primary and secondary objectives, but failed to achieve orbit; next flight set for January, 1965 (T-II-C); 17 development flights planned; five TITAN II core vehicles (A version), 12 full TITAN III's (C version); operational in 1966; an unmanned rated version—TITAN III-X—being studied as more cost/effective booster for satellite launches.



Missiles

AADS-70 (Army)—CONTRACTORS: Hughes/Douglas/FMC, RCA/Beech, competitive component development contracts. DESCRIPTION: Field army ballistic missile defense system, mobile. STATUS: No decision to develop system has been made; component development funded at $5 million in FY '65; expected to provide basis for program definition in 1965.

ADVANCED SURFACE MISSILE SYSTEM (Navy)—CONTRACTORS: Raytheon, Boeing, Sperry Rand, General Electric, Westinghouse, RCA & Hughes, pre-program definition contracts. DESCRIPTION: Fleet air-defense weapon for the 1970 time period; to have capability against aircraft and certain types of air-to-surface missiles; will replace the 3-T systems currently in the fleet. STATUS: Pre-program definition; program definition planned in mid-1965 and development contract by 1966.

ALFA (RUR-4) (Navy)—CONTRACTORS: Navy, prime; Avco, frame; Naval Propellant Plant, propulsion. DESCRIPTION: ASW, surface-to-underwater; weight, 500 lbs.; solid propulsion; H.E. depth charge; range, 1,000 yds.; guidance, free-flight. STATUS: Operational; deployed on desroyers and cruisers; being replaced by ASROC.

ANTI-SATELLITE WEAPON (Army/Air Force)—CONTRACTORS: Boeing, AF program; Hughes, terminal guidance (IR), AF program; Douglas, THOR and ZEUS vehicles and support services; A. D. Little, Operations Analysis. DESCRIPTION: Consists of both NIKE-ZEUS and THOR-AGENA w/terminal stage programs; intercepts have been accomplished at "hundreds of miles," according to Secretary McNamara. STATUS: Operational according to DOD; however, major portions of the AF program are uncompleted at the Johnston Island test site.

ARM I (Navy)—CONTRACTORS: None announced. DESCRIPTION: Longer-range, smaller anti-radiation missile than SHRIKE for armament of F-111B and A-7A aircraft. STATUS: Advanced development.

ASROC (RUR-5A) (Navy)—CONTRACTORS: Honeywell, prime; Sangamo Electric, sonar; GE, torpedo; Librascope-General Precision, fire control. DESCRIPTION: ASW, surface-to-underwater; weight, 1,000 lbs.; solid propulsion; warhead, nuclear or conventional torpedo; range between 1,800 yds. and 8 mi.; guidance, unguided. STATUS: Operational on DE, DD, DLG, & heavy cruisers; one "live" weapon fired in 1962 Pacific nuclear tests; extended range version in pre-program definition phase; version adaptable to TERRIER launchers being developed.

ASTOR (Mk-45) (Navy)—CONTRACTORS: Westinghouse, prime. DESCRIPTION: Mark 45 ASW, underwater-to-underwater torpedo; weight, over 2,000 lbs.; solid propulsion; warhead, nuclear; range, about 11 n.mi; guidance, wire. STATUS: In production; deployed on hunter-killer submarines.

ATLAS (PGM-15) (Air Force)—CONTRACTORS: TRW Space Technology Laboratories, systems engineering & technical direction; GD/Astronautics, frame; GE/Burroughs/Arma, guidance; Rocketdyne, propulsion; GE/Avco, re-entry vehicle. DESCRIPTION: ICBM; weight, 266,000 lbs.; liquid propulsion; warhead, nuclear; range, 5,500-9,000 mi.; ATLAS "E" and "F" series inertial guidance, ATLAS "D" radio inertial. STATUS: 13 squadrons operational at 11 bases; total number of missiles, 126; phaseout of ATLAS D's begun; ATLAS Standard Launch Vehicle developed for AF space programs; ATLAS launches from WTR being used in conjunction with ATHENA launches at Green River, Utah, in an effort to develop scaling laws for re-entry bodies (Advanced Ballistic Re-entry Systems program).

BOMARC A (AIM-10A) (Air Force)—CONTRACTORS. Boeing, prime; IBM/Westinghouse, guidance; Aerojet/Marquardt, propulsion. DESCRIPTION: Surface-to-air interceptor; weight, 15,000 lbs.; liquid booster/ramjet propulsion; warhead, nuclear; range, 200 n.mi.; guidance, command via SAGE; speed, MACH 2.5; ceiling, over 68,000 ft. STATUS: All A missiles at five bases operational in northeastern U.S. to be phased out by the end of 1965; production completed; costs $20 million per year to operate system.

BOMARC B (AIM-10B) (Air Force)—CONTRACTORS: Boeing, prime; General Precision Aerospace/Westinghouse/IBM, guidance; Thiokol/Marquardt, propulsion. DESCRIPTION: Surface-to-air; weight, 16,000 lbs.; solid booster/ramjet propulsion; warhead, nuclear; range, more than 400 n.mi.; guidance, command via SAGE; speed, Mach 2.7. STATUS: Three bases operational production completed; the 188 B models will be distributed among the eight bases after the A model is phased out.

BULLPUP (AGM-12 B & C) (Navy-Air Force)—CONTRACTORS: Martin, systems cognizance; Maxson Electronics Co., production; AMF, liquid engine; Thiokol, solid propulsion; Naval Propellant Plant, solid propulsion (motor loading). DESCRIPTION: Air-to-surface; range, 3-6 mi.; guidance (visual reference), radio-link command. BULLPUP A: Solid propulsion; warhead, 250-lb. H.E. BULLPUP B: pre-packaged liquid motor; warhead, 1,000-lb. H.E. STATUS: BULLPUP A deployed with Atlantic and Pacific Fleets; operational with U.S. Air Force & NATO units; training version (ATM-12) being procured by both services; being produced in Europe for NATO.

CLOSE-SUPPORT ASSAULT WEAPON (Navy)—CONTRACTORS: Navy Bureau of Weapons and Johns Hopkins Applied Physics Lab, prime; United Aircraft Norden Div., guidance. DESCRIPTION: Ship-to-shore; outside dimensions compatible with TERRIER shipboard installations; solid propulsion; warhead, high explosive; range, 30-mi. minimum; guidance, inertial and terminal. STATUS: Carried as a line item in FY '66 budget; funding to some degree dependent on results of guidance system flight tests at WSMR aboard SERGEANT missiles.

CONDOR (AGM-53) (Navy)—CONTRACTORS: In-house, Naval Ordnance Test Station; RFP's issued to nine firms: Martin, Douglas, McDonnell, Hughes, NAA-Columbus, Northrop, Raytheon, Grumman & Bendix. DESCRIPTION: Air-to-surface; configuration classified. STATUS: Development; intended for use with Navy version of F-111.

DAVY CROCKETT (M-388) (Army)—CONTRACTORS: In-house project directed by Army Weapons Command at Rock Island, Ill. DESCRIPTION: Surface-to-surface; solid propulsion, bazooka-launched; warhead, sub-kiloton nuclear; guidance, free flight; two launchers—vehicle-mounted or carried by two men. STATUS: Operational in Europe; $13 million provided in FY '64 budget; 3 per ROAD battalion; seen as defensive rather than offensive weapon to prevent overrun of Europe.

ENTAC (MGM-32) (Army)—CONTRACTORS: Nord Aviation, prime. DESCRIPTION: Anti-tank; weight, 37 lbs. with launcher; solid propulsion; warhead, shaped-charge H.E.; range, 6,600 ft.; guidance, wire-guided; man-portable. STATUS: Operational; procurement complete; will be replaced by TOW.

FALCON (AIM-4 A, C, E, F/26A/47A) (Air Force)—CONTRACTORS: Hughes, prime; Hughes, guidance; Thiokol, AIM-4/26 propulsion; Lockheed Propulsion, AIM-47 propulsion. DESCRIPTION: Air-to-air; weight (AIM-4/47), more than 100 lbs.—(AIM-26), more than 200 lbs.; range 5 n.mi.; supersonic; solid propulsion; warhead, H.E. (except for AIM-26); AIM-4A, and 4E, active radar homing guidance; AIM-4C, and 4F, IR homing; AIM-26 model has nuclear warhead and hybrid IR radar homing. STATUS: Operational; buy-out of 4E, 4F and 26 in FY '62; AIM-47 is the armament for YF-12A (A-11).

GENIE (AIR-2A) (Air Force)—CONTRACTORS: Douglas, prime; Aerojet-General, propulsion. DESCRIPTION: Air-to-air; weight 800 lbs.; unguided; solid propulsion; warhead, nuclear; range, 6 n.mi.; guidance, free flight; supersonic; proximity fuzing. STATUS: Procurement complete; operational on F-101B and F-106; improved version cancelled.

HAWK (MIM-23A) (Army)—CONTRACTORS: Raytheon, prime; Raytheon, guidance; Aerojet-General, propulsion. DESCRIPTION: Surface-to-air; weight, 1,275 lbs.; solid propulsion; warhead, H.E.; range, 22 mi.; guidance, semiactive radar homing; 100-45,000-ft. ceiling; provides defense against medium and low-flying aircraft and cruise-type missiles. STATUS: Operational; deployed in Europe, Panama, Okinawa, U.S. (13 battalions); bought by Sweden and Israel; R&D being conducted to adapt selected HAWK units to an anti-tactical ballistic missile; NATO producing; Japan also plans buy.

HIBEX (ARPA/Army)—CONTRACTORS: Boeing, prime; Hercules and Aerojet, propulsion. DESCRIPTION: Experimental program in high-energy propellants; cone shaped missile; performance classified; solid propulsion. STATUS: Development; accelerations of 800 to 1,000 g's goal; flight test program of 10 vehicles to be conducted at WSMR beginning late this year.

HONEST JOHN (MGR-1) (Army)—CONTRACTORS: Douglas/Emerson Electric, prime; Hercules, propulsion. DESCRIPTION: Surface-to-surface; weight, 5,900 lbs.; single-stage solid propulsion; warhead, nuclear; range, 12 mi. (M-31), 20 mi. (M-50); unguided. STATUS: Operational; M-50 being deployed in Europe; to be replaced by LANCE; procurement complete.

HOUND DOG (AGM-28) (Air Force)—CONTRACTORS: North American, prime; Autonetics, guidance; Pratt & Whitney, propulsion. DESCRIPTION: Air-breathing air-to-surface standoff missile; weight, 9,600 lbs.; turbojet propulsion; warhead, nuclear; range, about 600 n.mi.; guidance, all-inertial; ceiling in excess of 50,000 ft.; Mach 2+. STATUS: Operational; to be launched from B-52G intercontinental bombers; procurement complete.

LANCE (XMGM-52) (Army)—CONTRACTORS: Ling-Temco-Vought, prime; Systron-Donner, guidance. DESCRIPTION: Highly mobile general-purpose missile; very light weight; pre-packaged storable liquid propellant; warhead, nuclear and H.E.; range, 3-30 mi.; guidance, Autonet inertial, one missile per launcher. STATUS: Large-scale development; eventually will replace HONEST JOHN and LACROSSE and perhaps LITTLE JOHN; division support weapon; to use multi-system test equipment.

LITTLE JOHN (MGR-3) (Army)—CONTRACTORS: Emerson Electric, prime; Hercules Powder, propulsion. DESCRIPTION: Surface-to-surface; weight, 800 lbs.; solid propulsion; warhead, nuclear; range, 10-mi.; unguided; supplements medium and heavy artillery in airborne divisions and air-transportable commands. STATUS: Two battalions activiated in 1961; each equipped with four launchers; air and helicopter transportable; may be replaced by LANCE.

M72 (Army)—CONTRACTORS: Hesse/Eastern Div., Flightex Fabrics, prime. DESCRIPTION: Light anti-tank rocket; weight, 4.5 lbs.; solid propulsion; warhead, H.E.; range, 500 yds.; guidance, free flight; carrier tube launcher; earlier called LAW. STATUS: Operational.

MACE (MGM-13A, CGM-13B) Air Force)—CONTRACTORS: Martin, prime; Goodyear/AC Spark Plug, guidance, Thiokol/Allison, propulsion. DESCRIPTION: Air-breathing surface-to-surface; weight, 18,000 lbs.; turbojet and solid propulsion; warhead, nuclear and H.E., range, over 650 n.mi. (Model A), over 1,200 n.mi. (Model B); guidance, Map-matching (A), Inertial (B). STATUS: Five MACE-A and one MACE-B squadron (in hard sites) deployed in Europe; two MACE-B squadrons on Okinawa in hard sites.

MAULER (MIM-46) (Army)—CONTRACTORS: GD/Pomona, prime; Hughes, guidance; Lockheed, propulsion; deHavilland, IR acquisition; Raytheon, radar; Burroughs, computer; FMC, carrier vehicle. DESCRIPTION: Surface-to-air; weight, 120 lbs.; solid propulsion; warhead, nuclear, H.E.; guidance, IR acquisition; highly mobile anti-aircraft and anti-missile missile; tracked vehicle; 9 missiles per launcher. STATUS: Development; suffering serious packaging problems: Army postponing more advanced models until after feasibility validation program has determined if system can be saved.

MAW (Army)—CONTRACTORS: McDonnell Aircraft Co. and Army Missile Command, development of competitive approaches to Medium Anti-Tank/Assault Weapon requirement; Ford Instrument Co., gyro package for Army version. DESCRIPTION: Surface-to-surface; solid propellant; range, 500-1,500 yds.; shoulder-fired; McDonnell version wire-guided; Army version two-degree-of-freedom, free rotor gyro. STATUS: Exploratory Development; competitive approaches to be fired off against each other in Summer, 1965, using a ZUNI test vehicle, and the best allowed to proceed into full-scale development.

MINUTEMAN (LGM-30) (Air Force)—CONTRACTORS: TRW Space Technology Laboratories, systems engineering and technical direction; Boeing, major contractor; Autonetics, guidance; Thiokol, first-stage propulsion; Aerojet, second-stage propulsion; Hercules, third-stage propulsion; Avco, re-entry vehicle. DESCRIPTION: 2nd-generation ICBM; weight, over 65,000 lbs.; solid propulsion; warhead, nuclear; 3 stages; range, over 5,000 mi.; guidance, all-inertial, target selected in seconds; 32-sec. reaction time. STATUS: MINUTEMAN II flight-test program (36 shots planned) began Sept. 24; over 700 MINUTEMAN I now operational; 1,000 missiles through FY '65; advanced version can be fired by airborne command posts; deployed in hardened and dispersed silos; MINUTEMAN II expected operational 1965, to be co-located with MMI; also some of the II's replace earlier models; MMII has greater accuracy and range/payload than I version.

NIKE-HERCULES (MIM-14B) (Army)—CONTRACTORS: Western Electric, prime; Western Electric, guidance; Hercules and Thiokol, propulsion; Douglas, airframe. DESCRIPTION: Surface-to-air, antiaircraft, tactical; weight, 10,000 lbs.; solid propulsion; warhead, nuclear or H.E.; range, 75 mi.; guidance, command; Mach 3+; ceiling in excess of 150,000 ft. STATUS: Over 80 batteries deployed in U.S. being turned over to National Guard; over 10 N-H batteries deployed overseas; Japan plans additional procurement; being equipped with HIPAR, a high power acquisition radar, and anti-tactical-ballistic-missile capabilities. Re-location of some Hercules batteries under consideration by JCS.

NIKE-ZEUS (XLIM-49) (Army)—CONTRACTORS: Western Electric, prime; Bell Telephone, guidance; Thiokol/Lockheed, propulsion; Douglas, airframe. DESCRIPTION: Antimissile missile, 3-stage; weight, 22,800 lbs.; solid propulsion; warhead, nuclear; range, 200-mi.; guidance, command; length, 48 ft.; diameter, 36 in.; fin span, 10 ft. STATUS: Missile is now part of NIKE-X missile "mix"; development, except as part of X, has ended; no intercept "failure" in more than a year of tests.

NIKE-X (Army)—CONTRACTORS: Western Electric, prime; Bell Telephone, guidance; Thiokol, ZEUS propulsion; Douglas, ZEUS airframe; Martin Marietta, SPRINT missile prime; Hercules and Lockheed, SPRINT propulsion. DESCRIPTION: Successor to ZEUS as an anti-ICBM system; uses a mix of ZEUS/SPRINT missiles and multi-function array radar (MAR). STATUS: Engineering development; funded at $334 million in FY '65 on accelerated development schedule, but deployment still deferred; tests to be conducted late this year with MAR at WSMR, New Mexico, could provide basis for deployment decision; deployment cost: $12-20 billion.

PERSHING (MGM-31) (Army)—CONTRACTORS: Martin, prime; Bendix guidance; Sperry Farragut, fuzing and aiming; Thiokol, propulsion. DESCRIPTION: Surface-to-surface; weight, 10,000 lbs.; two-stage solid propulsion; warhead, nuclear; range, approx. 400 n.mi.; guidance, inertial; transported on FMC M474 tracked vehicles; replaced REDSTONE. STATUS: Flight test program completed; troop firings from Ft. Wingate, N.M., to White Sands being conducted; number of launches per unit to be increased; West Germany organizing two battalions; first U.S. PERSHING battalion deployed to Germany in April.

PHOENIX (AIM-54) (Navy)—CONTRACTORS: Hughes Aircraft Co., prime; Rocketdyne, propulsion. DESCRIPTION: Air-to-missile for use with the F-111B fighter aircraft; each aircraft will be able to carry six missiles. STATUS: Development.

POLARIS (UGM-27 A, B, C) (Navy)—CONTRACTORS: Lockheed, prime; GE/MIT/Hughes/Honeywell/Raytheon, guidance and fire control; Aerojet-General/Hercules, propulsion; Lockheed, re-entry vehicle; Nortronics, checkout; Autonetics/Sperry, SINS; Westinghouse, launching equipment; Vitro, systems engineering coordination and training; Systron-Donner, ignition programming. DESCRIPTION: Underwater- and surface-to-surface; weight, 30,000 lbs.; solid propulsion; warhead, nuclear; range, 1,200 n.mi. (A-1), 1,500 n.mi. (A-2), 2,500 n.mi. (A-3); guidance, all-inertial. STATUS: 17 subs operational each with 16 missiles; A-1 aboard first five submarines; A-2 aboard subs 6-18; A-3, operational in August, 1964, aboard subs 19-41; total of 41 POLARIS subs authorized; deployed in Atlantic and Mediterranean; Pacific deployment to begin by end of year; British to buy A-3 missiles from U.S. B-3 program definition included in FY '65 budget; missile for NATO MLF surface force concept.

QUAIL (ADM-20C) (Air Force)—CONTRACTORS: McDonnell, prime; McDonnell Electronics, guidance; GE, propulsion; Thompson Ramo Wooldridge, ECM equipment. DESCRIPTION: ECM-carrying decoy which simulates B-52 bomber to enemy radar; turbojet powered; range, 250 mi.; guidance, gyroscopic autopilot. STATUS: Deployed at SAC bases; carried by B-52; procurement completed FY '61; advanced version with 400-mi.-range has been flight tested.

REDEYE (MIM-43) (Army)—CONTRACTORS: GD/Pomona, prime; Hughes, IR seeker; Atlantic Research, propulsion. DESCRIPTION: Surface-to-air; weight, 22 lbs.; solid propulsion; warhead conventional; guidance, IR-homing; length, 44 in.; diameter, 2.75 in. STATUS: Development to continue Congress denied FY '65 procurement request; tests against helicopters and jets at NOTS successful.

REGULUS I (RGM-6) (Navy)—CONTRACTORS: Ling-Temco-Vought prime; Sperry, guidance; Allison, propulsion. DESCRIPTION: Surface-to-surface; weight, 14,000 lbs.; turbojet and solid propulsion; warhead, nuclear; range, 500 n.mi.; guidance, inertial; speed, about 600 mph; ceiling, approx. 40,000 ft. STATUS: Five REGULUS subs with 17 missiles are operational now; 3 subs (8 missiles) will be phased out in FY '65.

SERGEANT (MGM-29A) (Army)—CONTRACTORS: Sperry Utah, prime; Sperry, guidance; Thiokol, propulsion. DESCRIPTION: Surface-to-surface; weight, 10,000 lbs.; solid propulsion; warhead, nuclear; range, over 75 n.mi.; guidance, inertial; uses drag brakes. STATUS: Operational; procurement complete; deployed in Europe; replacement for CORPORAL; West Germany buying system.

SHILLELAGH (MGM-51A) (Army)—CONTRACTORS: Philco Aeronutronic, prime Picatinny Arsenal/Amoco Chemicals Corp., propulsion; Aeronutronic, guidance. DESCRIPTION: Surface-to-surface; lightweight; solid propulsion; warhead, nuclear or H.E.; guidance, command; vehicle-mounted for use against field fortifications, armor and for close-in support of troops. STATUS: Initial procurement in FY '65; to use multi-system test equipment; engineering development stage began in FY '64; to be installed on Gen. Sheridan assault vehicle; also being considered for use on helicopters.

SHRIKE (AGM-45A) (Navy)—CONTRACTORS: Naval Ordnance Test Station-China Lake, prime; Texas Instruments, guidance and control; North American Rocketdyne (McGregor), propulsion. DESCRIPTION: Air-to-surface, anti-radar; solid propulsion; guidance, passive radar homing. STATUS: Operational; armament for Navy and Air Force tactical aircraft.

SIDEWINDER I-C (AIM-9D) (Navy, Air Force)—CONTRACTORS: Naval Ordnance Test Station, technical direction; Philco, guidance; Naval Ammunition Depot, McAllister, motor loading; Rocketdyne (McGregor), propellant. DESCRIPTION: Air-to-air; weight, about 155 lbs.; solid propulsion; warhead, H.E.; range, more than 2 mi.; guidance, IR. STATUS: 1A deployed with Navy and Air Force; 1-C version being procured as replacement for 1A; NATO-built version now in production.

SPARROW III-6B (AIM-7E) (Navy)—CONTRACTORS: Raytheon, prime; Raytheon, airframe, control, guidance; Aerojet-General/North American Rocketdyne (McGregor), propulsion; McDonnell/Benrus Watch Co., launcher. DESCRIPTION: Air-to-air; weight, 350 lbs.; solid propulsion; warhead, conventional; range, 5-8 mi.; guidance, semi-active CW homing; Mach 2.5-3; ceiling, over 50,000 ft. STATUS: Earlier models operational with carrier aircraft; SPARROW III-6B prime armament for Phantom II (F-4B) and other high-performance interceptors; British F-4 buy expected to include SPARROW missiles.

SPRINT (Army)—CONTRACTORS: Martin-Orlando, prime; Hercules Powder/Lockheed Propulsion Co., propulsion; Bell Telephone Laboratories, guidance. DESCRIPTION: High-acceleration missile for low-altitude interception of ballistic missiles; nuclear; missile will be popped out of silo before motor is ignited; to be part of the missile mix in a NIKE-X battery. STATUS: Development; SQUIRT vehicle to be used to test materials and components for SPRINT at White Sands Missile Range; pop-up tests to prove silo ejection concept and mechanism under way at Martin Orlando plant.

SRAM (Air Force)—CONTRACTORS: None selected. DESCRIPTION: Air-to-surface defense-suppression missile for use with the B-52 or the Advanced Manned Strategic Aircraft. STATUS: Advanced development.

STANDARIZED MISSILE (Navy)—CONTRACTORS: None announced. DESCRIPTION: Fleet air-defense missile to replace TARTAR-TERRIER and give Navy a single missile to perform both missions; longer-range targets would be engaged by adding a booster to the shorter-range weapon; similar to the homing TERRIER now being procured. STATUS: Development; expected to be procured initially in 1967-68.

SUBROC (UUM-44A) (Navy)—CONTRACTORS: Naval Ordnance Laboratory, technical direction; Goodyear, prime; General Precision Aerospace, guidance; Thiokol, propulsion; General Precision Librascope, fire control. DESCRIPTION: Underwater-air-underwater antisubmarine missile depth bomb; solid propulsion; warhead, nuclear; weight, 4,000 lbs.; length, 21 ft.; diameter, 21 in.; range, 25-30 mi.; guidance, inertial. STATUS: Production scheduled for installation in Thresher-class subs; operational evaluation under way.

SS-10 (Army)—CONTRACTORS: Nord Aviation, prime; GE, U.S. licensee. DESCRIPTION: Surface-to-surface, primarily antitank; weight, 33 lbs.; solid propulsion; warhead, conventional; range, 1,600 yards; wire guided. STATUS: Operational with U.S., French and other NATO and Western units; battle-tested in North Africa; U.S. replacing with ENTAC.

SS-11 (Army)—CONTRACTORS: Nord Aviation, prime. DESCRIPTION: Surface-to-surface antitank, also helicopter-to-surface; weight, 63 lbs.; solid propulsion; wire guided; warhead, conventional; range, 3,800 yds. STATUS: Operational, to be used with airborne units and Army helicopters.

TACTICAL PROBE (Navy)—CONTRACTORS: Bendix, prime: DESCRIPTION: Surface-to-air; multiple, interchangeable payloads for each mission; booster, TERRIER or TALOS from shipboard installations; high-impulse second stage; range, 50-300 mi.; parachute descent. STATUS: Program definition; a new study has been authorized, and is under way, to evolve a cheaper program.

TALOS (RIM-8E) (Navy)—CONTRACTORS: Bendix, prime; Vitro, systems engineering; McDonnell/Hercules Allegany Ballistics Lab., propulsion; Sperry, guidance; GE, launching gear. DESCRIPTION: Ship-to-air; weight, 7,000 lbs.; solid and ramjet propulsion; warhead, nuclear; range, 65 n.mi.; guidance, radar beam riding/semi-active homing; Mach 2.5. STATUS: Operational aboard cruisers Galveston, Little Rock & Oklahoma City and three Albany-class DEG's; Long Beach, nuclear-powered cruiser, has advanced TALOS; "3-T" get-well program increasing reliability.

TARTAR (RIM-24B) (Navy)—CONTRACTORS: Vitro, systems coordination engineering; Applied Physics Lab, design and development; GD/Pomona, assembly and test; Raytheon, guidance; Aerojet-General, propulsion (motor loading); Sperry Farragut, fuze (target detection device). DESCRIPTION: Ship-to-air; weight, 1,500 lbs.; solid dual-thrust motor; warhead, conventional; range, 10 n. mi.; guidance, beam-riding; Mach 2. STATUS: Operational; installed aboard 27 guided missile destroyers and one cruiser equipped with TALOS; get-well program progressing satisfactorily; CVA Kennedy will also have TARTAR.

TERRIER (RIM-2E) (Navy)—CONTRACTORS: Vitro, systems engineering; GD/Pomona, prime; GD/Pomona, guidance section; Sperry, radar; Hercules Allegany Ballistics Laboratory, propulsion; Northern Ordnance, launching gear. DESCRIPTION: Ship-to-air; weight, 3,000 lbs.; 27 ft. long; solid propulsion; warhead, conventional; range 10 n.mi.; guidance, radar beam-riding or homing; Mach 2.5. STATUS: Operational aboard two attack carriers, 6 cruisers, and 12 missile frigates; get-well program progressing satisfactorily.

TITAN I (HGM-25A) (Air Force)—CONTRACTORS: TRW Space Technology Laboratories, systems engineering and technical direction; Martin, prime; Bell/Sperry, guidance; Aerojet-General, propulsion; Avco, re-entry vehicle. DESCRIPTION: ICBM; weight, 220,000 lbs.; LOX/RP-1 fueled; warhead, nuclear; range, 5,000 mi.; guidance, radio inertial; 90 ft. long; 2 stages. STATUS: Operational; 54 missiles at 5 bases.

TITAN II (LGM-25C) (Air Force)—CONTRACTORS: Martin, prime; TRW Space Technology Laboratories, system engineering and technical direction; AC Spark Plug, guidance; Aerojet-General, propulsion; GE, re-entry vehicle. DESCRIPTION: ICBM; weight, 330,000 lbs.; N_2O_4 and Aerozine-50 storable fuels; warhead, nuclear; range, over 5,000 mi.; guidance, inertial; 115 ft. long; 2 stages; greatest payload and range of any U.S. ICBM; basic core vehicle for TITAN III booster. STATUS: All 54 missiles operational; one squadron (18 missiles) operational at Davis-Monthan AFB; one (18 missiles) at McConnel AFB and one (18 missiles) at Little Rock AFB.

TMRBM (Air Force)—CONTRACTORS: None announced but likely to be the same team producing the second and third stages of MINUTEMAN II. DESCRIPTION: A transportable mid-range missile to fill the gap left by cancellation of MMRBM; it would use the top two stages of MM II and the MM II guidance system; would weigh more and be less mobile than MMRBM, but could be developed for approximately one-third the cost; reaction time also less than MMRBM's; employment concept much the same as that of the Russian-deployed missiles in Cuba in 1962. STATUS: Study by the Air Force at DDR&E direction; results to be presented late this month or early December; could be approved, on a contingency basis, in FY '66 budget.

TOW (Army)—CONTRACTORS: Hughes, prime. DESCRIPTION: Antitank; weight, 160 lbs.; solid propulsion; warhead, H.E.; wire guided; optically tracked; tube-launched. STATUS: Development; follow-on to ENTAC; firings being conducted at Army Missile Command.

WALLEYE (Navy)—CONTRACTORS: Naval Ordnance Test Station-China Lake. DESCRIPTION: Guided air-to-surface bomb; weight, 1,000 lbs., equipped with movable fins; propulsion type, none; warhead, high-explosive; range, several miles; guidance, TV contrast homing guided by pilot. STATUS: Engineering development; industry invited to bid on production of missile.

ZUNI (Navy)—CONTRACTORS: Naval Ordnance Test Station, prime; Hunter-Douglas, propulsion. DESCRIPTION: air-to-surface; weight, 107 lbs.; solid propulsion; warhead, conventional; range, 5 n.mi.; unguided; STATUS: Operational; designed for use on jet fighter and attack aircraft.

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SPECIAL REPORT

HYBRID ROCKETS

Hybrid Concept Developing Rapidly Toward Goal of Tripropellant Engine

Several U.S. firms are finding solutions to major problems still blocking exploitation of hybrid advantages; French report progress

by John F. Judge

HYBRID PROPULSION systems soon will be a major contender for a wide variety of space and military missions and may prove to be the key to the ultimate in chemical propulsion—the tripropellant rocket.

At least four major propulsion firms have scored significantly in the two major problem areas in hybrids—achieving high performance and attaining efficient throttleability. Industry experts are convinced the technology is ready to move into flight development programs.

As usual, the major customers are somewhat more conservative—but they all admit that industry does "have a handle" on the problems.

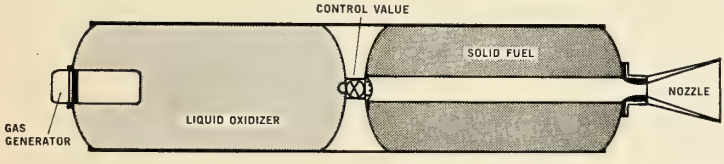
The hybrid rocket (see accompanying box) or solid-liquid engine is an old concept; a significant amount of work was done in this area during the 1950's in the United States. The prime mover was the Naval Ordnance Station at China Lake, Calif., which actually flew a first-generation hybrid—although the device was not a true hybrid.

The biggest single advantage of a hybrid is its ability to use reactions denied to other propulsion systems. Many propellant combinations having optimum performance require reactions between solids and liquids. This potential alone was deemed sufficient to keep funding the concept, even though other propulsion systems moved rapidly into operational use over the last 10 years.

A second hybrid advantage is that high-density specific impulse can be achieved with concurrently good Isp. Specific impulse values of well over 300 (1,000/14.7, shifting equilibrium) can be reached with well-known oxidizers and fuels.

High-energy propellant systems raise this level much higher.

The third great advantage is safety—both in processing and in field use.



A HYBRID ENGINE consists of a liquid oxidizer, a solid fuel and associated hardware. In its basic form, the liquid oxidizer is valved into a chamber containing the solid grain. Ignition is usually hypergolic.

Neither of the propellants will support combustion by themselves in a true hybrid rocket. The solid-fuel portion resembles a solid rocket in that the combustion chamber is within the solid grain. The liquid section is similar to tankage and pumping elements in a liquid rocket.

This type of hybrid is sometimes called the forward hybrid to distinguish it from a reverse hybrid, which has its oxidizer in a solid state and the fuel in a liquid form. The reverse hybrid is a special case.

In the forward hybrid, the liquid oxidizer is injected into the solid fuel area. Ignition takes place on contact with the solid grain if the propellant system chosen is hypergolic. There is then a combustion process down the length of the solid grain and the products are exhausted through a nozzle creating thrust.

There are no unique components in a hybrid. The injection methods and patterns are the same as those for liquid rockets. The combustion chamber is similar to a normal solid rocket where the grain acts as insulation. Nozzle systems and thrust vector control methods are similar to the other classical reaction engine families.

Thrust termination and restart is accomplished in the simple hybrid by shutting down and re-opening the oxidizer flow system. Variable thrust is usually instigated by varying the flow of the liquid oxidizer to the solid fuel chamber.

This is the basic hybrid and all of the above operations are standard. The technical problems with the system in achieving performance levels competitive with solids and liquids are somewhat more complex.

Separation of the reactants makes fire, rather than explosion, the primary hazard, and lessens the need for extensive safety control procedures.

The fuel grain can be as inert as a rubber tire. Normal grain defects do not affect performance, since the quantity of combustion gases produced is limited by the quantity of injected liquid and not by the total exposed area of the solid.

A double malfunction—excess liquid plus a badly cracked grain—would be required to produce a pressure surge in a hybrid. A mechanism for detonation propagation does not exist.

All of these advantages contribute to an inherent high reliability.

● **Europe leading?**—The hybrid rocket is the one area in which foreign technology may pass that of the U.S.—if it has not already done so. The French are known to be active through their Office National D'Études et de Recherches Aérospatiales (ONERA).

ONERA specialists launched a 6.25-in.-dia. hybrid from the range at Ile du Levant on April 25, 1964. The thrust was varied over a 5 to 1 ratio during the flight.

Most of the French work so far made public has been described by M. Barrère, A. Moutet and Maurice Pugibet, all of ONERA, in various papers presented at International Astronautic Congresses.

Barrère's analysis of the specific-impulse advantages, flexibility and density potential is in general agreement with that of U.S. specialists.

● **Specific impulse**—Storable liquid-propellant systems are in the 320-sec. Isp range, according to Barrère. This level can be raised significantly through the use of fluorine derivatives as the oxidizer and the introduction of metals or metal hydrides into the fuel.

The metals and the metal hydrides are solids; their use in a liquid medium results in gels or emulsions. These thixotropic suspensions pose problems in stability and flow and also limit the amount of metal additives. The percentage of metal additives is directly related to maximum performance.

Barrère says the maximum Isp in a high-energy storable liquid system is about 360 seconds—an increase of 40 seconds over the best non additive system.

The solid rocket is also a storable powerplant and its basic Isp is in the 300-second area. Again, metal additives can raise this significantly, and there is no limit to the amount of additives involved. Barrère claims, and most U.S. experts agree, that a gain of 25 seconds can be achieved with a standard solid composition by adding an alloy of lithium and beryllium. Of course, many special compositions developed in classified U.S. programs may have specific impulses in excess of this.

PROPELLANT		COMPOSITION	I_s	I_{sp}
SOLID	Present	Ammonium perchlorate Al + plastic	267	455
	Future	Ammonium perchlorate LiBe + plastic	290	377
LIQUID	Present	$HNO_3 - DMH$	276	348
		$HNO_3 - N_2H_4$	283	362
		$N_2O_4 - DMH$	285	336
		$N_2O_4 - N_2H_4$	292	356
		$H_2O_2 - DMH$	278	345
		$H_2O_2 - N_2H_4$	282	355
	Future	$ClO_3F - N_2O_4$	295	360
		$N_2O_4 - B_5H_9$	306	337
		$H_2O_2 - B_5H_9$	312	311
		$ClF_3 - N_2H_4$	294	444
HYBRID	Present	$H_2O_2 - Al$ + plastic	289	435
		$HNO_3 - Al$ + plastic	273	414
	Future	$NO_2ClO_4 - N_2H_4$	295	428
		$ClF_3 - LiH$	293	445
		$ClF_3 - Li$	318	369
		$N_2O_4 - BeH_2$	351	530
		$H_2O_2 - BeH_2$	375	566

TABLE I—Barrère's listing of Isp and density impulses of storable propellants under standard conditions.

In any event, Barrère says, it would be difficult to exceed an Isp of 360 seconds in a space environment with either storable liquids or solid propellants.

The hybrid, however, can exceed these values by a significant amount. Table I, prepared by Barrère and presented to the 14th International Astronautical Congress in Paris in September, 1963, illustrates the theoretical Isp under standard conditions.

Most of the promising fuels—such as the metal hydrides or reactive metals embedded in plastic—are solids. The best storable oxidizers are liquids. The ideal combination is in the hybrid system.

PROPELLANT	COMPOSITION	I_s	I_{sp}
LIQUID	$O_2 - H_2$	391	109
	$O_2 - N_2H_4$	335	365
	$F_2 - H_2$	410	185
	$F_2 - N_2H_4$	363	476
	O_2-F_2 - DMH	345	398
HYBRID	$F_2 - LiH$	363	476
	F_2-O_2 - plastic	343	412
	$F_2 - BeH_2$	395	604
	$O_2 - BeH_2$	371	486
	$F_2 - AlH_3$	353	551

TABLE II—Impulse data on cryogenics as compiled by Barrère. Propellants in both tables are in use in U.S. for hybrids.

The highest specific impulses are reached through reactions involving cryogenic propellants. Barrère's data in the accompanying Table II compares cryogenic hybrids—where the liquid is in the cryogenic state—and normal cryogenic all-liquid systems.

● **Historic problems**—The French cite only the hybrid's advantage in thrust modulation, but this area has been the major problem in development of hybrids. Throttling is keyed to performance and the entire problem is integral with combustion phenomena in the hybrid.

There were four major blocks to effective development of the hybrid. These were poor fuel utilization, low combustion efficiency, low burning or regression rates in the fuel, and a significant loss of performance in throttling.

All of these are within the combustion area. The principal route to their solution has been in understanding the hybrid combustion process. Industry spokesmen say they have solved these problems. The customers agree that the approaches look valid, but they insist on more definitive data.

Combustion work in hybrids is extensive. Hybrids may be the first propulsion concept to reach operational use *because* there is a basic understanding of the combustion mechanism.

● **Industry angle**—Four propulsion firms have a vested interest in hybrids—United Technology Corp., Reaction Motors Division of Thiokol Chemical Corp., Aerojet-General Corp. and Lockheed Propulsion Co. The technology of the first three is described in detail later in this report.

Lockheed Propulsion's hybrid rocket development is under contract to the Army. Most of the work is classified, but Jerry Makepeace, vice president and Technical Director of LPC, says hybrids will be selected for certain missions in the future.

"I don't think you can make any hard statements about hybrid use right now," says Makepeace. "With hybrids, we are not talking about any kind of massive breakthrough—such as comparing atomic energy with chemical. Hybrid advantages show up only for specific applications and purposes.

"Since the hybrid state of the art is nowhere near as far along as liquids and solids," continues Makepeace, "it is not surprising to me that no unique and tremendous advantages for hybrids have yet appeared for any specific application. But I think they will and I think they will be incremental."

The Rocketdyne Division of North American Aviation is now working on

some aspects of hybrids under Air Force funding. But the general feeling here is one of skepticism.

"In general it is fair to say that we see applications of the hybrid as being somewhat limited." says a Rocketdyne spokesman. "In other words, whereever we see an application for a hybrid, we can generally see either a liquid or a solid rocket that does just about as well."

If the concept is used at all, Rocketdyne specialists predict, high-density hybrids and those using fairly available propellants are the most likely candidates.

Rocketdyne's in-house work is quite limited. Although it has been in progress for some time the current effort is not very large. No direct work is now being carried out except in the peripheral area of combustion.

The only other major propulsion firm is Hercules Powder Co., where work in hybrids ceased about a year ago. Hercules developed an operating hybrid several years ago, but the technology in general is on the shelf at the Wilmington, Del., firm.

Dr. Lyman G. Bonner, Director of Development, Chemical Propulsion Div., told MISSILES AND ROCKETS that while actual development work has ceased, Hercules is competent in the field. The status quo at Hercules is subject to change at a moment's notice should the customers evince adequate interest in hybrids.

● **Applications**—There are as many potential applications for tailored hybrids as there are mission propulsion requirements. D. D. Ordahl of United Technology specifically mentions attitude control, space propulsion and large boosters.

The stop/start ability of hybrids in any form makes them particularly appealing in attitude control applications. Any combination of propellants can be used, including those aboard for other propulsion means.

In space engine use, the hybrid can be designed to a fairly high specific impulse—the main requirement in this area. But there are other needs, such as long-term storability with frequent intermittent operation and very precise impulse control or modulated thrust.

Taken together, these needs can best be met by a reliable hybrid—which provides the added advantages of multiple thrust units and efficient packaging in odd-shaped spaces.

In the large booster area, hybrids can show an Isp increase of some 20 to 40 seconds over conventional solids. Such a booster would be competitive with storable liquids on a specific-impulse basis. Where a volume restriction exists, it would be superior.

● **Hybrid market problems**—There are, as usual, four major customers for the hybrid propulsion concept—NASA, Air Force, Navy and Army. All have funded the technology in one form or another, with the Navy having the longest history of involvement. All have existing contracts with industry.

The military work is all classified, but there is no indication that any of the funded hybrid effort includes a development and flight-test program. Total funding is in the $3-5-million range, and this is augmented by in-house programs at UTC, RMD and Aerojet.

The breakdown excludes the Army, since work for that service, funded out of the missile arm at the Redstone Arsenal, is completely classified.

NASA has one contract with UTC on a variable-thrust hybrid engine and another, out of the Marshall Space Flight Center, involves Aerojet-General in studies of auxiliary propulsion on *Saturn*-class vehicles.

The general feeling at NASA is that hybrids have not yet satisfactorily demonstrated reliable combustion efficiency and fuel utilization in the throttling mode. Robert W. Ziem, Solid Propulsion Technical Chief, says he is not satisfied that the basic combustion problems are solved. But Ziem is quite optimistic about the progress of technology.

He feels that the state of the art is "getting in shape" and another year of work in the problem areas should put the hybrids in line for mission programs. NASA will continue to fund the technology; the annual level of funding is expected to climb to around $0.75 million.

In general, says Ziem, hybrids are promising, especially for space applications. In addition, the hybrid leads directly into the tripropellant area.

The Air Force is by far the most optimistic of the services in hybrid work. Dr. Leon Green of the Research and Technology Division says the concept will probably be funded on a flight-program basis in Fiscal Year 1967.

Air Force optimism is directly related to its success with current contracts—especially the work at UTC. This service usually puts a premium on high performance, with somewhat less emphasis on other aspects such as handling and the field environment. The Air Force will continue the present work at about the same levels of funding.

The Navy is the hybrid's roughest customer. The mission and supporting system limitations are particularly severe —more so than those of any other service. At the moment, the Navy has contracts with Reaction Motors on a reverse hybrid, and two programs at Arojet-General.

Two of these efforts will not be continued—the reverse hybrid at RMD and an engineering program at Aerojet-Sacramento. Funding of the propellant work at Aerojet-Von Karman Center will continue.

In spite of these actions, the Navy is maintaining an open mind on hybrids.

The curtailment of activity arises from a scarcity of development funds and the fact that no hybrid system has yet demonstrated enough of a performance increase with respect to liquids and solids to warrant a Navy effort right now.

Navy spokesmen emphasize to M/R that hybrids have not been dropped. Propellant work—the area which will lead to a pay-off in terms of performance and mission use—will be supported. The Navy's action is more an interim judgment than a final one, and the door will still be open when hybrids reach a level of development compatible with the Navy's needs.

The Advanced Research Projects Agency in the Dept. of Defense has been the primary source of research funds into propellants and the combustion work on hybrids. ARPA does not have any direct interest in hybrids, since all of its programs have been transferred to the various services. Some basic work in oxidizers remains, but this will be phased out into the services by 1965.

● **Tribrids**—The ultimate in chemical propulsion performance is an engine with the highest possible combustion zone temperature coupled to an exhaust stream with the lowest possible molecular weight.

Granting that the ideal use of high-energy propellants is in a liquid/solid rocket (taking advantage of the physical state of the propellants) the next step is to lower the molecular weight.

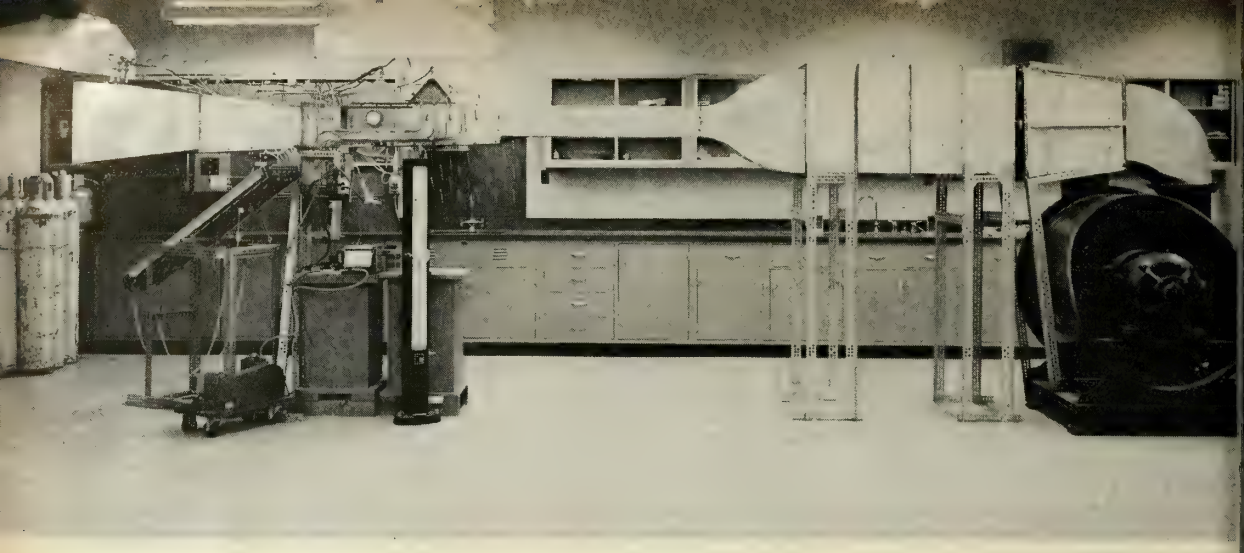
High temperature is usually reached by burning a metal in the fuel. Barrère of ONERA lists beryllium, lithium, boron and aluminum as the most promising metals. Low molecular weight is achieved by bringing hydrogen into the system.

Calculations show that the optimum Isp is achieved when about 10 hydrogen atoms are available for each metal atom. Chemical synthesis of such products is just not possible.

The solution is a tripropellant system —with one element being liquid hydrogen. The system would contain a liquid oxidizer, cryogenic or storable; a solid fuel containing a high proportion of metal or metal hydride additives; and, finally, hydrogen.

Essentially, this is using a hybrid rocket with a high flame temperature to heat hydrogen—an approach similar to the thermonuclear rocket. Hélène Moutet and Maurice Pugibet of ONERA are experimenting with such systems.

The potential of this route is recognized at NASA, but there are no unclassified tripropellant/hybrid programs in the U.S. at the moment. ■



UTC RESEARCHERS use this hybrid wind tunnel in combustion studies. Grain is simulated by a pair of porous plates above and below the window. Combustion flow and mixing phenomena can be studied under a host of operational variables.

SPECIAL REPORT HYBRID ROCKETS /UNITED TECHNOLOGY

SUNNYVALE, CALIF.—The striking aspect of the hybrid rocket work at United Technology Center is the intense drive into the fundamentals of the combustion processes involved in such propulsion schemes.

The United Aircraft Corp. division decided three years ago to approach hybrids from this angle after studies funded by the Advanced Research Projects Agency led to the conclusion that no real solution to any of the recognized difficulties in the development of such engines would be achieved without understanding the combustion process.

This attitude went hand-in-glove with the realization that the hybrid combustion process differed greatly from both liquid and solid engines. D. D. Ordahl, UTC's assistant manager for advanced technology, says the basic phenomena are now understood and many of the processes have been reduced to mathematical equations.

Ordahl insists UTC knows enough to handle a hybrid development program on a fixed-cost basis over a 12-to-18-month period. This sentiment is completely in line with that of Barnet R. Adelman, UTC's president. Adelman told MISSILES AND ROCKETS that if the *Polaris B-3* propulsion system bidding were to come two years from now, UTC would go in with a hybrid.

Adelman has little faith in the future of large solids in the 260-in.-dia. range with respect to the technology of current programs. The outspoken executive said some time ago that the only route to large rockets is through hybrids (M/R, April 27, p. 27).

● **Combustion approach**—Ordahl says the basic problems retarding hybrid development are a generally low recovery of theoretical Isp, uneven fuel burnout along the length of the combustion chamber, an unpredictable decay in thrust level with time, extreme losses in efficiency with throttling and extremely low burning rates.

Actual combustion in a hybrid occurs in a relatively narrow zone significantly distant from the surface of the solid fuel. This distance is roughly $\frac{1}{10}$ the distance to the aerodynamic boundary layer.

The combustion zone is fed by vaporized fuel and gases from the decomposition of the solid and also vaporized or gaseous oxidizer from the fluid phase. Heat from this combustion zone is conducted or radiated to the solid surface and to the incoming fluid or gaseous phases of both fuel and oxidizer.

Combustion occurs where these gaseous materials meet, and the diffusion of the products proceeds away from the combustion chamber.

This general description of the phenomena has been established and most workers in the field of hybrids agree with its tenets. How much agreement exists is evidenced by the similarities in the approaches to efficient hybrid engines.

Ordahl maintains UTC now understands the complex mechanisms behind the general description to the point of being able to design efficient hybrids. The firm has demonstrated propellant utilization in the 98.5% to 100% range.

● **Engine design significant**—An important consideration in hybrid engine design, says Ordahl, is that the liquid or gas phase coming from the injector does not contact the surface of the solid after the initial reaction. The solid does not "know" what kind of oxidizer is being used in any given application, and the combustion process is essentially the same for all cases.

The combustion picture emerging from work at the firm is different from other work at research centers in the U.S. But every time UTC researchers have developed an experiment, its results invariably agree with the theory as developed at UTC.

One result of the lack of surface contact between oxidizer and solid in a hybrid is that the main task of an injector is not to place oxidizer on the fuel surface but to diffuse and vaporize the liquid phase so it can mix with the material in the combustion zone.

Ordahl says an analysis of the combustion process leads to the conclusion that the major factor in controlling efficiency is designing to promote effective mixing of the vaporized fuel and oxidizer and preventing the escape of unreacted material from the motor.

Ordahl says tests have shown this mixing to be critical. The major answer to good mixing at UTC is the introduction of spoilers or turbulence devices toward the aft end of the combustion chamber.

In UTC's case, the spoiler is a proprietary foamed ceramic usually impregnated with a resin to extend its life in the hot gas environment (M/R, Oct. 21, 1963, p. 39). The ceramic adds only a little weight to the entire engine, but succeeds in promoting 100% mixing. The shape and configuration may differ from engine to engine but its function is the same. It extends into the solid core beyond the grain

surface and kicks the flow radially into the center of the combustion area.

In addition, proper matching of injector characteristics with grain design can achieve essentially complete fuel utilization. This has been experimentally demonstrated with motors.

● **Achieving faster burning**—The combustion-analysis work also led to the solution of the problem of low combustion rates in hybrids. The fuel consumption rate, says Ordahl, is primarily dependent on the rate of heat input and the amount of energy needed for vaporization.

Thus the ideal fuel should be one with the lowest possible latent heat of decomposition or vaporization. It follows that the products formed should be readily converted to reactable gases.

Ordahl defines a hybrid as a system containing two propellants, neither of which is capable of sustaining combustion by itself. The thrust-generating reaction demands the operation of both together.

With respect to the ideal fuel just mentioned, UTC researchers achieved substantial rate increases by promoting non-self-sustaining chemical reactions in the fuel surface. Additives are used to perform an energy release function.

Systems under study at the moment have regression rates similiar to those in a low-energy solid propellant.

Ordahl and his colleagues found that the regression rate of a hybrid depends on the flow of the liquid phase in a manner similar to the dependence on pressure of the burning rate in a solid.

The main effect of this dependence of fuel regression rate on mass flux is in the design of the solid grain. UTC has reached constant thrust by using designs that provide progressive surfaces.

● **Thrust modulation**—The obvious method of throttling a hybrid is to modulate the liquid phase flow. But this causes the problem that for many propellant systems the fuel flow from the grain does not vary in direct proportion with the oxidizer flow injected at the head end.

The direct result is a change in the oxidizer to fuel-flow ratio over the throttling range. Optimum performance is achieved at a single value of this ratio, and throttling produces a performance loss.

Once again, the fundamental combustion work at UTC relates the extent to which fuel flow varies with oxidizer flow to a relationship between fuel-regression rate and oxidizer flow.

In hybrid systems tailored for specific thrust-time profiles, the mixture ratio shift can be minimized by grain design. Ordahl says good fuel utilization can be achieved because the required propellant weights are accurately defined.

The real throttling problem occurs in demand-thrust applications in which modulation is random. To handle this in a straightforward manner means having excesses of propellants at either end of the oxidizer/fuel ratio—thus imposing a weight penalty.

● **Mixing methods**—There are two more efficient methods—aft-end injection and use of pressure-sensitive hybrid fuels. In the aft-end method, UTC injects oxidizer into the head end so that the mixture downstream of the grain is fuel-rich. Then additional oxidizer is added downstream of the grain in amounts necessary to maintain the total flow to the required oxidizer/fuel proportions.

UTC has demonstrated the feasibility of the aft-end injection method in 5-in. motor firings. Ordahl mentions the obvious disadvantages in that the system requires an additional liquid-flow circuit, and attainment of an 8:1 thrust modulation required a 64:1 variation in the head end oxidizer flow—a variation difficult to achieve with simple valving.

The second solution—using pressure-sensitive hybrid fuels—demands a complete understanding of both the propellant chemistry and the mechanics of combustion. Most hybrid fuels are not pressure sensitive and their regression rates are not significantly affected by combustion pressure.

Additives are used to render these fuels pressure-sensitive at UTC. These same additives evolve from the regression rate work.

The additives create a pressure-dependent heat source in the solid grain if the gasesous products are reactive. The additives must not result in self-sustained reaction during combustion, or the hybrid grain more nearly resembles a conventional solid—and the design becomes a liquid-augmented solid engine.

The additives can be particulate or actually tied into the solid polymer. UTC has an enormous amount of experimental data in both of these subareas, with the actual experiments being suggested by the combustion concept as it evolved.

● **Experience and funding**—UTC has a total of approximately $2 million in outside hybrid funding. This includes a Navy contract with ARPA funds covering the fundamentals of hybrid combustion. This is now in its fourth year.

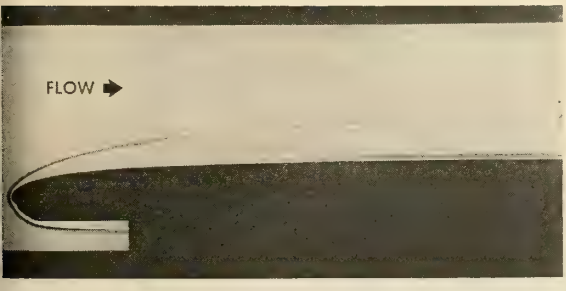
The firm is in its third year on a classified high-energy hybrid system under Air Force sponsorship. A third contract with NASA is just beginning on the use of hybrids in a gas generator for testing components in a hot gas environment. The fourth contract is the recent NASA throttling hybrid study.

W. A. Rains, manager of the firm's Hybrid Propulsion Branch told M/R that complex grain shapes are a key approach at UTC. This has led to greatly improved length/diameter ratios and has contributed to improved combustion efficiency.

Rains feels the pressure-sensitive fuel approach to throttling has the greatest promise in the long run. But the propulsion expert did not rule out any other approach including aft-end injection or a combination of methods. Each hybrid is tailor-made for its specific mission profile. The approach is dictated by a number of compromises.

As an example, Rains points to aft-end injection. While it adds plumbing and weight in reaching a throttling requirement, it may eliminate the need for spoilers in the combustion area.

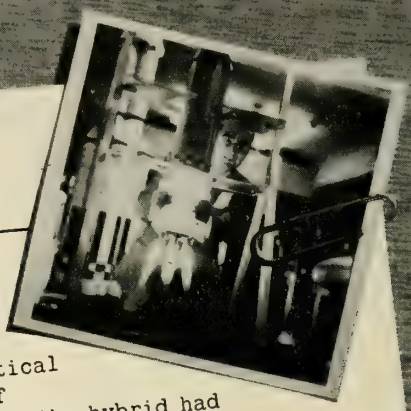
Rains says UTC has not yet deter-





LEFT: Schlieren photograph of a lab hybrid in operation using a Plexiglass fuel and oxygen as the oxidizer. RIGHT: Shadowgraph of the same system. The combustion zone is away from the grain surface after the initial oxidizer contact. Laminar flow is set up and the mixing problem is apparent. Distance from flame and combustion zones to surface of solid fuels is visible.

Are advanced propulsion methods your special concern?



SUBJECT: HYBRID ENGINES

Company: United Technology Center

In 1959, UTC initiated a company-funded program aimed at developing a truly practical hybrid engine. Because of a basic lack of understanding of its combustion phenomena, the hybrid had never been anything more than a laboratory curiosity.

UTC demonstrated the feasibility of the hybrid. And as a result, the Advanced Research Projects Agency, Air Force, and the Navy funded additional r & d efforts by UTC.

Now, after four years of intensive research, the hybrid is ready for full-scale development.

NASA has awarded contracts to UTC to investigate hybrids for two different applications. Hybrid systems twice as powerful as any yet developed will be used to test solid propellant systems components. And UTC will demonstrate the feasibility of a hybrid hover engine capable of being stopped and restarted and throttled from 250 to 2,000 pounds of thrust.

More important is the relationship of hybrids to other complete propulsion systems. Recent detailed studies have now shown that even for the most stringent requirements of volume and weight-limited air-launched missiles, hybrids can produce substantially greater total performance than most storeable systems. And this performance is combined with highly significant advantages of safety, operational flexibility and economy.

Further applications are virtually unlimited: back-pack propulsion units; multimillion-pound launch vehicles; primary propulsion or attitude control for missiles and long-duration space missions.

In short: UTC has added a new and practical dimension in rocket propulsion capability.

For complete details, write UTC, Sunnyvale, California.



United Technology Center

DIVISION OF UNITED AIRCRAFT CORPORATION

U A

mined where the tougher control problems come into a given hybrid. This is being studied. In the case of demand thrust, the requirement of staying on the correct oxidizer/fuel ratio all the way easily poses the toughest test for a hybrid.

● **Tests aid competitive position**—In addition to the combustion work at UTC, an extensive testing program has been in effect for some time. The extent and success of this was made clear during a recent de-briefing after UTC won a competitive hybrid contract. The other industry bidders found that the testing and data accumulation at UTC had a decisive effect on their winning the competition.

Test rockets have ranged from 1 in. in diameter to 18 in., with the most recent being a 5,000-lb.-thrust glass-wound hybrid. Various combinations of both metallized and non-metallized fuels have been fired with gas, cyrogenic, storable and high-energy oxidizers.

Cumulative burn times for the many discrete propulsion systems range from 15 seconds to more than 5,599 seconds. Well over 900 individual firing have been logged.

This heavy involvement in testing has bolstered the confidence of the firm in its fundamental approach and ability to move beyond mere studies and feasibility programs into tactical propulsion systems, space propulsion and secondary propulsion schemes.

UTC has designs for 120-in.-dia. hybrids, and even eyes the larger solid boosters from a hybrid approach. The firm is convinced that funding is the only barrier between the hybrid technology as it now exists and operational propulsion systems. No engineering or technical problems are anticipated. ■

SPECIAL REPORT — HYBRID ROCKETS

/THIOKOL/RMD

DENVILLE, N.J.—Emphasis on pressure-sensitive grain development, avoidance of inert spoilers and a drive to set up equations accurately describing combustion efficiency characterize the hybrid work at Reaction Motors Div. of Thiokol Chemical Corp.

Under the direction of Steven J. Tunkel, Manager, Research Engineering Dept., RMD is firmly committed to a package approach to hybrids. Hybrid technology started at RMD in August, 1959, with portions of the *Falcon* improvement program. Since that time, company- and government-funded programs have brought the state of the art at RMD to the threshold of a full-scale development program ending in an operational hybrid engine.

The criterion at RMD, as with the other major firms in the business, is to attain the highest possible performance while meeting engine function specifications such as stop/restart and throttling. The key to high propellant performance is an understanding of the combustion process in the hybrid.

RMD researchers realized that the hybrid is essentially different from both liquids and solids in this respect. The next step came through mass fraction studies, which clearly showed the need for high burning rates.

Understanding the regression rate is critical to the successful performance of a hybrid engine, whether during sustained constant thrust or thrust modulation. RMD researchers also realized early in the game the critical importance of combusion efficiency.

● **Mixing, efficiency linked**—Combustion efficiency is intimately related to optimum mixing of the fuel and oxidizer in the combustion zone. The RMD approach is through regression-rate development in the solid grain and liquid injection system development.

When RMD researchers probed variable thrust, they found the hybrid concept far more complex than early studies indicated. The general loss of performance in throttling caused by changes in the oxidizer/fuel ratio became the major problem.

Early work in regression rate led RMD into the pressure-sensitive grain area. Additives to the basic fuel grain induce this characteristic, in addition to the grain's inherent reaction to oxidizer flow rates.

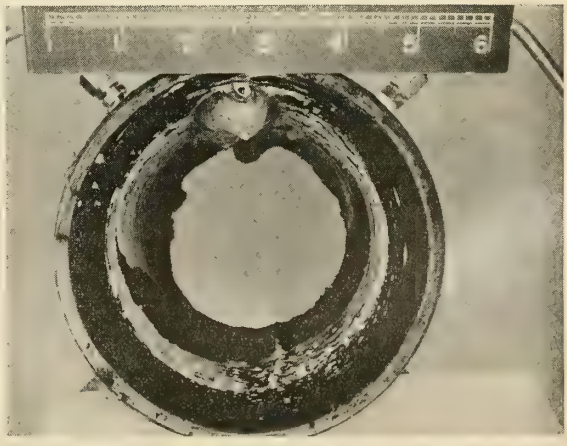
To achieve 8 to 1 throttling purely through the effect of oxidizer flow rate on the solid grain, the liquid flow variation at the injection end is in the area of 64 to 1. This is too large a variation for a practical throttling scheme—and all firms doing hybrid work agree on this.

Throttling can be handled by adding oxidizer aft of the grain to regain optimum O/F ratios in throttling modes. This also performs a mixing function in the combustion chamber. One drawback is the additional pumping and transfer hardware necessary.

Tunkel firmly believes that high-efficiency injection methods and pressure-sensitive grains should be pursued before falling back on aft-injection or

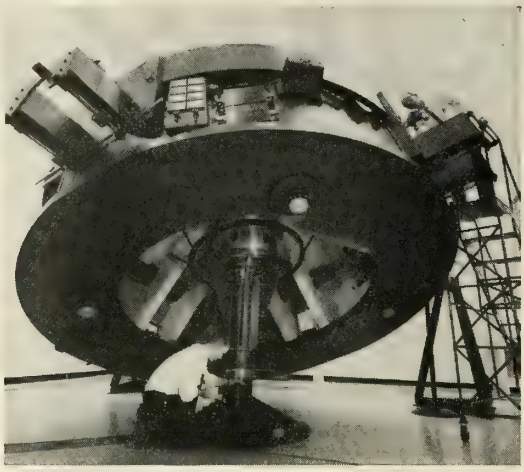


LEFT: End view of 5-in.-dia. motor chamber before firing.



RIGHT: End view of same motor after firing.

WHERE RIGIDITY IS CRITICAL



The Problem: Provide a low inertia Apollo spacecraft simulation platform that can be loaded with six tons yet will not deflect more than four-thousandths of an inch at its edge.

The Solution: **Unique Bonded Honeycomb Sandwich Design by Hexcel R & D.**

Measuring 13 ft. 6 in. in diameter, the platform is shaped like a gigantic bass drum perched atop a slender pedestal. It balances upon a pressurized dry nitrogen gas bearing which virtually isolates it from friction and vibration—similar to conditions of weightless space flights. The platform is balanced so precisely that no persons are allowed in the room with it during experiments—body movements would create minute air currents which could cause the device to move in a manner unlike normal space flight.

Deflections and loads are sensitively balanced by the Hexcel design resulting in minimum overall distortion.

Thick core slabs of honeycomb (in various densities) were assembled in pie sections, sawed in the round, machined to dimensional accuracy, then bonded en masse to surface skins at room temperature using a cold-bonding process.

Hexcel R & D, under contract to Minneapolis-Honeywell, was responsible for the design, honeycomb manufacture and platform fabrication direction. Delivery was on time. Actual maximum edge deflection of the platform is .0029 in., exceeding specification.

The Hexcel objective is both to manufacture the widest range of honeycomb core products available, and to provide solutions to unusual high strength-light weight structural problems.

HEXCEL'S DESIGN OUTPERFORMS ALL OTHERS (This chart compares an earlier Hexcel Design. The platform was smaller but for the same purpose as the work discussed above.)

	Company A Design	Company B Design	Company C Design	Hexcel Design
Platform	Riveted Aluminum	Welded Mild Steel	Welded Stainless Steel	Alum. Sandwich Construction
Platform Weight	—	—	—	406 lbs.
Table Inertia Capacity	20-40 Slug Ft² Max.	26 Slug Ft² Pitch 33 Slug Ft² Roll 14 Slug Ft² Yaw	65 Slug Ft² Pitch 65 Slug Ft² Roll 33 Slug Ft² Yaw	126 Slug Ft² Pitch 126 Slug Ft² Roll 210 Slug Ft² Yaw
Max. Load Capacity	400 lbs.	1100 lbs.	900 lbs.	4000 lbs.
Deflection at Max. Load	—	½"-1"	—	.0007"-.0016"

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the addition of turbulators. This course, says Tunkel, avoids the mass fraction penalties inherent in aft-end injection or spoilers.

● **Reverse hybrid effort**—RMD is the only firm with active work in the reverse hybrid—a concept using a solid oxidizer and liquid fuels. Reverse hybrids have not met with much enthusiasm from any of the government agencies.

But a reverse hybrid, says Tunkel, has a pressure-sensitive grain of the first order. It is also easily throttled, although limited in throttling ratio. There is an inherent high burning rate.

The main problems with a reverse hybrid are the limited number of energetic oxidizers available in solid form and the fact that it is not a true hybrid —in the sense that the reaction is self sustaining. It is more a liquid-augmented solid rocket.

But the research into such hybrids provided RMD with graphic evidence of the potential performance in pressure-sensitive grains.

Tunkel is now working with pressure-sensitive grains involving polyurethane and PBAA. The characteristic is induced through chemical additives to the base grain. Other additives are used to attain a smooth grain surface in shutdown—since this surface condition is critical to good, smooth restarts.

The pressure-sensitive additives are discrete entities in the grain and not chemically hooked into the binder. Tunkel believes the operational characteristics are primarily due to a concentration effect—with the particle size contribution being a second-order effect.

The additives themselves are proprietary, but the result is an all-fuel solid grain. There are no metals involved. RMD sticks to castable, case-bonded grains and tries to avoid extrusion.

● **Grain-design considerations**—Although the problems with demand-thrust hybrids can be described in segments, Tunkel says grain design must be coupled to injector design.

Avoidance of the turbulator approach means introducing turbulence in the downstream combustion area without resorting to inert components. Injection design and grain shape figure heavily in the RMD methods.

Introducing a liquid into the solid portion of a hybrid involves the same essential elements as in all liquid engines. The three classical parameters are injection angle, droplet size and droplet velocity.

Tunkel uses these three elements to create a mixing turbulence in the combustion section. The problem then involves engineering studies, laboratory tests, and propellant system component characteristics.

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Each propellant system may have different values assigned to the three variables and these values are arrived at through both theoretical and experimental analysis.

● **Exhaust systems**—RMD has given considerable thought to the types of nozzles demanded by specific hybrid designs. Materials of construction range from ablative and heat-sink graphites to radiatively and regeneratively cooled refractory metal composites.

In the regeneratively cooled designs, RMD would use the liquid phase of the hybrid system, and since a large amount of OF_2 experience has been accumulated at the Division, it is safe to assume this has been tested as a coolant.

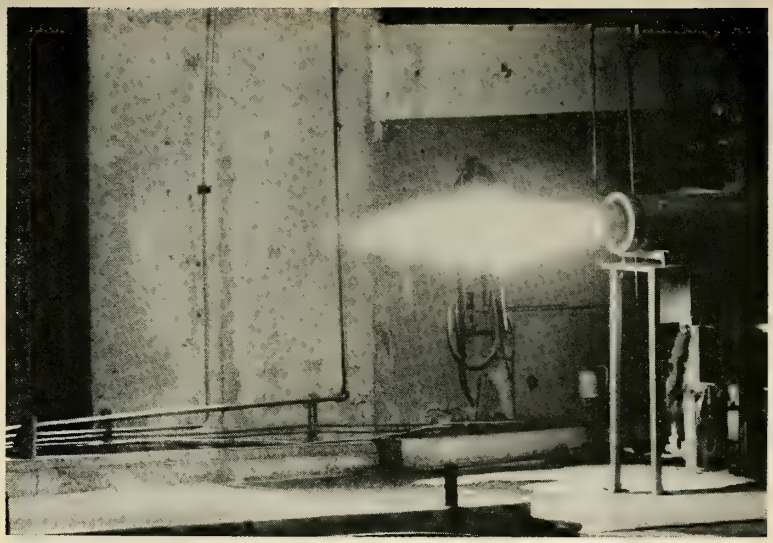
For space applications, finned-nozzle cooling schemes have been investigated. Tunkel, for one, does not consider the inert components as a major problem area, but will not dismiss them as easily solvable in any particular engine use.

Reaction Motors has more than 300 test firings in hybrid engines, and this does not include ignition tests. These include engine diameters from 2.5 in. up through 10 in., with varying chamber pressures and thrust levels.

Tunkel and his group have demonstrated delivered performance in the 92% to 95% range. RMD is confident a flying hybrid can be developed in an operational development program.

Oxidizers developed and fired at RMD include OF_2, flox, N_2O_4, chlorine trifluoride, perchloryl fluoride blends, IRFNA and others. The fuels have been standard binders and additives. RMD has also developed metal-free grains. RMD has experience and data in metals and metal hydrides including lithium, titanium, zirconium hybrids and boron, aluminum and beryllium metals.

There is only one contract currently in existence at RMD—a reverse hybrid program funded by the Navy's BuWeps. There will be no follow-on funding on this contract.



10-IN.-DIA. APT-1050 metal-free solid and Flox oxidizer motor fired last May at RMD reached 500 lbs. thrust with a chamber pressure of 80 psia. The 10-second head end injection firing shown is a restart after a shorter ignition run. The fuel grain was in two sections, to determine regression into grain fissures, but none occurred. The firing was followed by successive restarts at increasing thrust levels, to 2,000 lbs. at 300 psia.

● **Ground test and use**—Laboratory facilities include both cold- and hot-flow test apparatus, including a well-used porous plat burner and a high-pressure, transparent-slab burner. RMD researchers are incoporating spectroscopic equipment and techniques into the hybrid lab test units. Shadow-graph and schlieren equipment is also in use.

In the applications area, Tunkel says space propulsion is a natural for hybrids. The RMD expert is also fairly sure that the major oxidizer will be OF_2 in such applications.

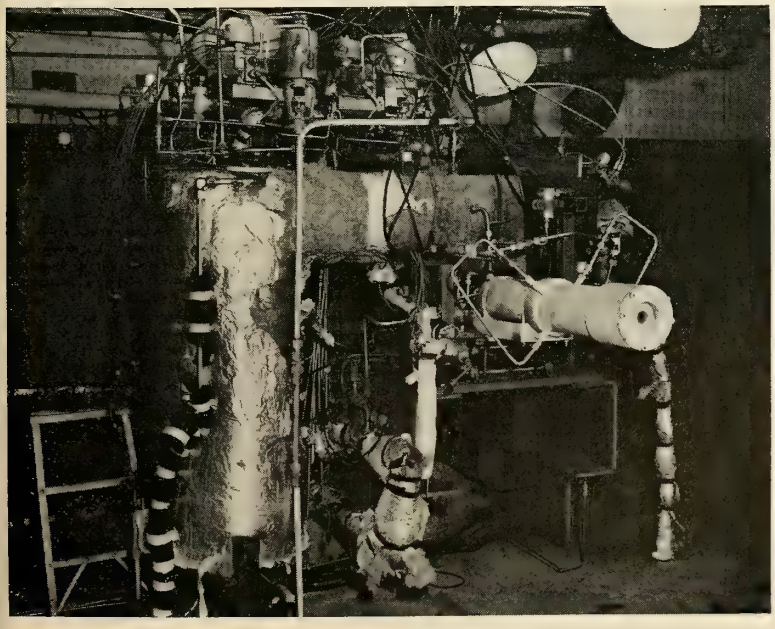
The Division has a long history with OF_2 and other space-storable propellants. Thiokol was the first to investigate OF_2 on an experimental basis.

Two other important areas of RMD hybrid-related experience are in prepackaged liquid engines and the highly successful LR-99 man-rated engine, which currently powers the *X-15*.

Both of these technologies are applicable to various hybrid programs. The experience in packaging complete propulsion systems with a minimum of moving parts as in the *Bullpup* powerplant family can be used in designing hybrid engines.

The throttling knowledge gained in creating the variable-thrust LR-99 covers a broad range of subsystems and hardware and includes a heavy percentage of experimentally derived experience. ■

RMD 5-IN. MOTOR is shown in test stand with afterburner in place. The after-burning concept adds oxidizer to the combustion stream aft of the fuel grain to regain an optimum oxidizer/fuel ratio. This was an early effort at RMD.



SACRAMENTO, CALIF.—Hybrid rocket technology at Aerojet-General is founded on a hard-headed hardware approach to the various potential application areas.

Centered in the firm's Sacramento, Calif., facility, with additional support as needed from specialists at the Von Karman Center in Azusa, the in-house programs focus on tailoring hybrids to specific mission areas.

Aerojet programs have demonstrated the feasibility of the hybrid concept in engines and pushed the state of the art to levels of high efficiency. The current effort is directed at collecting design details and information in propulsion configurations most interesting to the specific customers.

Under the direction of T. C. Bowden, hybrid projects manager at the Solid Rocket Plant, hybrid work is almost strictly pragmatic.

Early work at the firm went into the combustion problem in a basic manner. But the insertion of baffles or spoilers into hybrid designs later on in the programs forced certain alterations in the fundamental combustion concepts.

Aerojet experts believe baffles are a practical necessity to achieve good mixing in the combustion area and thus reach reasonable combustion efficiencies and regression rates for volume-limited mission applications. But the use of baffles altered the mathematical model developed by Aerojet for regression rate laws to the extent that the specific program is being modified and computerized to handle the changes.

Aerojet is probing deep into the baffle area—trying to determine what makes a good baffle in a given application while incurring the minimum weight penalty associated with their use in the first place.

● **Test background**—There is a significant amount of cold flow and simulated hybrid combustion research data at Aerojet. The lab test information has proven realistic in respect to actual hybrid firings. It is continuing with dynamic X-ray movies of the combustion phenomenon.

Aerojet has more than 100 full-scale test firings to its credit. These were planned to operate in practical ranges—1,000-psi chamber pressures and usable thrust levels. The firm has accumulated what its spokesmen feel is real and actual data in OF_2 firings. They also feel this information actually is real and actually represents such hybrid systems.

Motors fired include the early 5.5-in.-dia. 500-1,500-lb.-thrust unit through 8.5-in.-dia. 2,000-5,000 lbs. thrust to 16-in.-dia. units with thrust levels from 6,000 to 12,000 lbs.

These engine firings evaluated everything from injector designs to fuel grain configurations. Aerojet experts do not anticipate any major technical problems in the inert components of a given hybrid configuration. Even combustion instability is not much of a problem with hybrids. There are minor fluctuations, but these do not cause hybrid instability, and the massively destructive type of instability found in other propulsion systems does not seem to be a characteristic of the hybrid powerplant.

● **Custom approach**—The key theme at Aerojet is that hybrids are essentially tailored to the specific mission. Mission analyses performed by the group bolster this. There are always a number of compromises and trade-offs available when designing for a detailed application.

As with the other major firings in the area, Aerojet does not anticipate great technical difficulties in designing and flying a sustained-thrust hybrid. The really complex problems arise with the demand-thrust requirement.

Bowden and his team list five approaches to throttling the hybrid:

—There is the straightforward method of merely changing the oxidizer flow rate. This almost immediately results in the engine going off the optimum fuel/oxidizer ratio. This differs with each system and there might be applications where a limited throttling can be achieved within overall mission performance specifications.

—A second route lies in programming the shape of the grain for those applications involving a known and fixed throttling cycle.

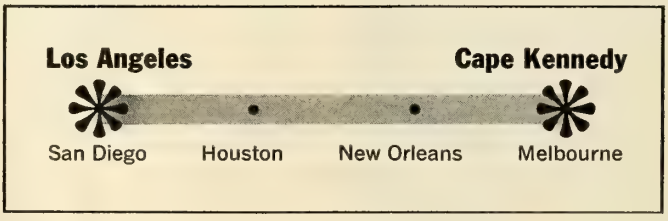
—The third is the development and use of pressure-sensitive fuels through additives. Aerojet has looked at this and developed information. The method has not been utilized because no specific application has arisen.

—There is aft-end injection which simply involves the addition of that amount of oxidizer required to again reach the optimum fuel/oxidizer ratio in the combustion area aft of the throttling function.

—The last is a compromise in which certain characteristics are selected and then enhanced by additives in the solid flow while throttling the liquid input. This is very similar to the presssure sensitive grain approach.

There is also an approach using a variable area throat in the nozzle.

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Aerojet experts maintain the simple regression rate model for solids is no good once you reduce a hybrid to practice. But analytical techniques have advanced considerably since the early days in developing solid and liquid rocket systems.

The pressure is off the major programs and such projects as the hybrid effort at Aerojet can use the corporate ability in computer programming and other analytical techniques. These can and are being used to investigate optimum oxidizer/fuel ratios in a variety of mission-oriented systems.

These studies and other inputs help to guide in-house hybrid management. The hardware approach at Aerojet has led to developments in the inert components areas almost as a matter of course. A specific example is injector design. This is an area of corporate competence demonstrated in a number of operational programs.

● **Self-generating expulsion**—Another more intriguing example is the approach Aerojet might take in solving the liquid injection hardware problems. This is a prime example of an ability to borrow technology from another area —in this case, liquids—and incorporate it into a given hybrid system.

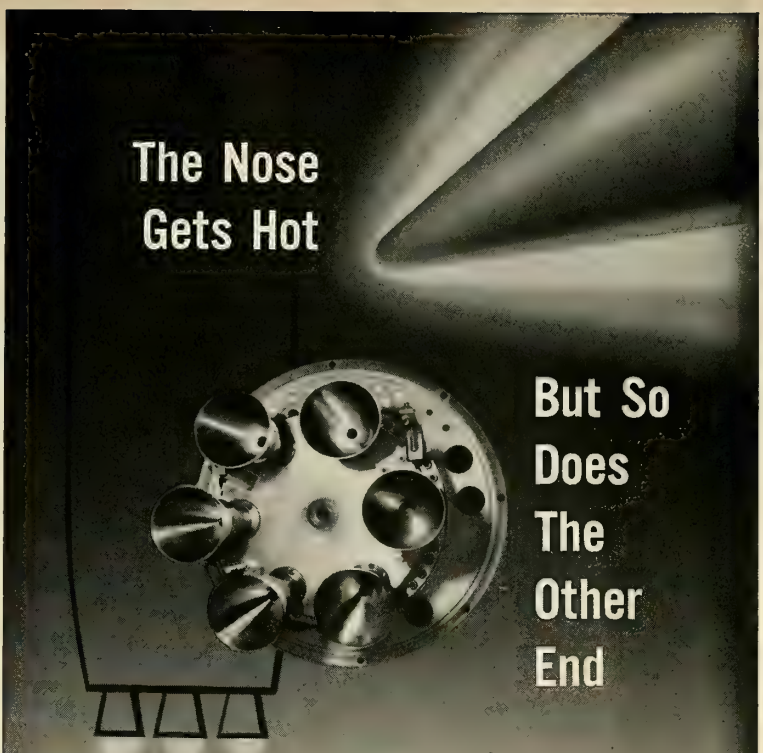
In 1959, Aerojet-Sacramento engineers conceived a lightweight vapor pressurization system (VāPak) which promised potential advantages over both pump and pressure-fed liquid delivery methods for liquid engines.

VāPak is similar in principle to a self-discharging insecticide can. The propellant is expelled by its own vapor pressure without a significant change in discharge pressure. No components or devices need function once liquid flow from a VāPak tank is initiated.

The VāPak system has applications in hybrids—especially in reducing the complexity of liquid expulsion hardware. In the last five years, Aerojet has demonstrated the principle with various earth-storable and cryogenic propellants. Long-duration storage and rocket engine tests have demonstrated the instant readiness and combustion characteristics of saturated propellants. Throttling tests have indicated a wide thrust range ability with a fixed area injector.

It is this throttling characteristic combined with the simplicity of the overall VāPak system that makes it attractive for hybrid applications—although the system is generally aimed at simplifying liquid rockets.

There are two major limitations to the VāPak system. The VāPak increases in weight as the chamber pressure is increased and rather accurate control of propellant temperature or composition is necessary to give accurate tank pressures.



The front-end heat transfer problems of hypersonic flight — nose cone configurations, spacecraft designs, ablative cooling methods — are studied in many laboratories. Aside from extensive programs in these well-publicized areas, however, Cornell Aeronautical Laboratory plays a leading role in solving the equally important but less understood problem at the other end of the missile: the destructive heating of the missile base.

The possible result of radiation, external burning of fuel-rich mixtures, and interaction and reverse flow of exhaust gases, base heating of rocket vehicles at high altitudes has been recognized as one of the major causes of mission failures.

Extensive Cornell Aeronautical Laboratory experience in shock tube technology has been adapted to this problem, with particular emphasis on the NASA/Marshall Space Flight Center Saturn program. CAL's researchers duplicate rocket motor operations at model scale through a pressure altitude ranging from sea level to 350,000 feet. Variations of base heating with Reynolds number have been investigated and base recovery temperatures determined. Resulting data have been highly significant in the design and subsequent successful flight testing of Saturn stages.

This applied hypersonics project is only one of the areas of research in which CAL's technical staff is leading the way.

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EXPERIMENTAL hybrid engine is shown mounted on a test stand at Aerojet's Sacramento facility.



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The VāPak is best utilized with lower chamber pressure upper stages. Aerojet experts feel these limitations are more than offset by the simplicity and potential performance of VāPak pressurization.

● **System operation**—In any closed container partially filled with a liquid, vapor is present at a definite pressure. Under equilibrium conditions, the pressure of the vapor is a function of the nature of the substance and its temperature. If no other gas is present, this vapor pressure is the total pressure in the container.

If an attempt is made to lower the pressure by draining off either liquid or vapor, the vapor-liquid equilibrium is upset and the liquid will boil, creating additional gas and tending to counteract the pressure reduction.

Heat of vaporization is required to change the liquid into gas and, in the absence of an external source, this energy must be supplied from that stored in the body of the liquid. The temperature of the liquid then falls along with the equilibrium vapor pressure.

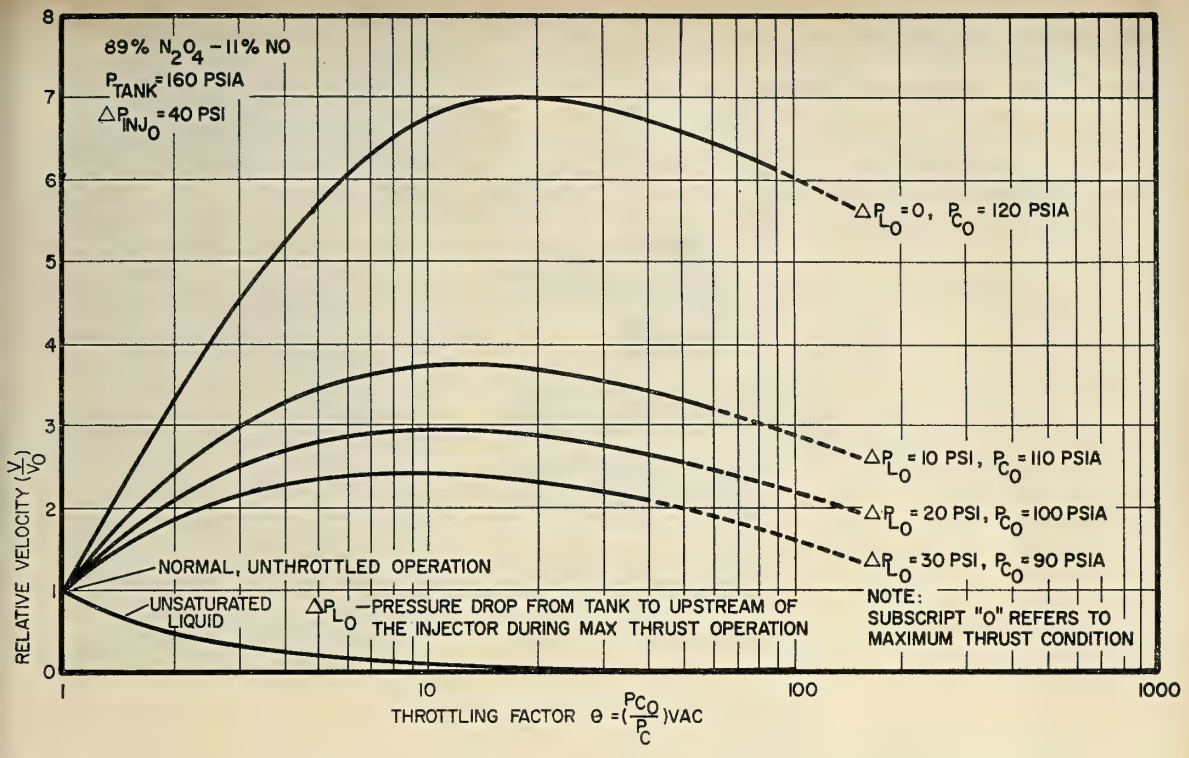
The magnitude of the decrease in pressure is a function of the proportion of liquid discharged and the specific thermochemical properties of the saturated liquid and vapor.

Calculations and tests at Aerojet's Liquid Rocket Plant have shown that it is possible to start with a tank almost completely filled with liquid, discharge all of this liquid and still have remaining in the tank some 70 to 80% of the initial pressure.

Variable thrust can be accomplished simply by throttling the propellant with the thrust chamber valves. Valve throttling a VāPak system causes formation of propellant gas in the lines—producing a flow condition similar to thrust control by gas injection.

Because the percentage of vapor formed is directly related to the degree of valve throttling, the saturated liquid system will show essentially the same characteristics as other gas injection

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ANALYSIS of saturated liquid valve throttling indicates that relative injection velocity improves with throttling. The reverse is true for conventional liquids. The VāPak system actually improves the mixing in throttling.

schemes, but with lighter weight and less complexity.

Analyses by Aerojet experts indicate that relative injection velocity increases with the throttling. The velocity reduces with the throttling of conventional liquids. A high propellant injection velocity is required for atomization and mixing.

In applying the concept to rocket engines, propellant selection is governed by its having a vapor pressure equal to the desired feed pressure at some reasonable temperature. The desired propellant vapor pressure can be obtained by either controlling liquid temperature or composition.

The temperature must be controlled prior to the propulsion operation with non-cryogenic or storable propellants. This conditioning has proven to be easy when the design temperature is selected at the maximum environmental temperature.

Once the initial propellant design temperature is reached, small heating and insulation provisions are adequate to maintain precise control of engine performance.

Aerojet engineers note that even with only 1 in. of ordinary foam plastic insulation, 4 watts/sq.ft. will maintain storable propellants at a temperature differential of 100°F. For *Falcon*-sized missiles, this leads to power requirements around 100 w. For an *Atlas*-size vehicle or a *Titan* first stage, this power level is approximately 10 kw.

● **Heavy test experience**—Aerojet has conducted over 38 VāPak expulsion tests with Earth cryogenic and storable propellants. There have been more than 120 VāPak rocket engine firing tests including 17 small-scale engine tests with a Lark powerplant. These latter tests evaluated VāPak engine combustion characteristics over a chamber pressure range of 60 to 330 psia.

There have been injector design tests, simulated zero-g runs and second-stage *Titan* hardware tests. In addition, 10 engine tests were run to investigate the saturated liquid variable thrust characteristics using *Titan* hardware.

Aerojet is currently studying a multifunctional auxiliary propulsion system for *Saturn*-type vehicles under a $150,000 study contract from NASA's Marshall Space Flight Center.

Aerojet is covering hybrid approaches to the problem which includes a thrust range of from 500 to 10,000 lbs. for various vehicle control modes. The study is designed to establish the most attractive concept of doing the job with the least number of thrustor units.

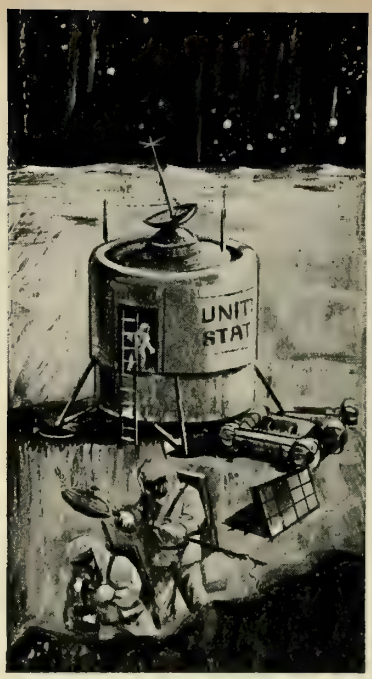
The 12-month study will determine the number and groupings of engines, their sizes and the propellant systems involved. At completion, the hybrid approach can then be compared to other methods. There is only small experimental hardware involved in this, and the project office at Huntsville indicates there is no firm system contract in mind at the moment.

Even the funding comes from the Center's in-house IR&D monies.

Aerojet has performed work for the Navy in certain facets of hybrid development. In this case, the initial work started back in 1960, and the latest phase involved collecting detailed design data in the system size ranges of interest to the Navy. Much of this work is classified. One engineering program funded by the Navy at Sacramento will be terminated at the end of the current contract. A second program into propellant research at the Von Karman Center Azusa, Calif., will be continued by the Navy.

In looking at applications, Bowden and his colleagues insist that weapons systems and space engines represent two entirely different areas with severely different requirements. A third area is somewhat less particularly defined and includes special applications such as gas generators, one-tank-several-combustors and other more particular uses. ■

beyond apollo—
the U.S. space program



4th annual NASA issue

november 30, 1964

MISSILES AND ROCKETS, the weekly of Space Systems Engineering, will publish its fourth annual NASA Issue on November 30, 1964.

This annual issue, now accepted as the authoritative publication on the nation's space agency, will examine future procurement plans of the National Aeronautics and Space Administration and three organizations allied with it in exploring the peaceful uses of space, Communication Satellite Corporation, Atomic Energy Commission and the U.S. Weather Bureau.

With major procurement for the Apollo manned lunar landing program now behind it, NASA is deep in the planning for new projects to expand man's knowledge of space, including such post-Apollo missions as the Lunar Logistic Supply System, Manned Orbital Research Laboratory, Extended Apollo, Project Voyager and Manned and Unmanned Planetary Probes. ComSat Corp., AEC and the Weather Bureau are drawing up plans for their growing participation in the peaceful use of space.

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missiles and rockets

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The Industry Week

Mergers and Acquisitions

Computer Sciences Corp., El Segundo, Calif., has announced the intention to acquire Documentation, Inc., the Bethesda, Md., firm that operates NASA's scientific information center. Agreement in principle has been reached and final action awaits approval by stockholders of DI and the boards of directors of both firms. Proposals calls for exchange of 480,000 outstanding shares of DI common stock for 160,000 shares of CSC common. . . . *Scientific-Atlanta, Inc., has reached preliminary agreement to acquire Southern Tool and Machine Co., Inc., of Anniston, Ala. ST&M manufactures precision machinery for the electronics, packaging and chemical industries. The Alabama firm is to be operated as a subsidiary of S-A in support of its overall growth plans.* . . . Irving Air Chute Co., Inc., Lexington, Ky., has acquired Payne & Associates, Inc., a Raleigh, N.C., research and development organization. The action was described as an effort on the part of Irving to expand the scope of its aerospace development work conducted at the firm's Para-Space Center in Glendale, Calif., by adding to existing R&D, design and engineering talent and capabilities. . . . *Glass-Tite Industries, Inc., Meadville, Pa., manufacturer of electrical and electronic components, has announced plans to purchase Clover Industries, Inc., Tonawanda, N.Y., for an unannounced amount of cash. Clover manufactures both metal and plastic industrial closures used in the missile/space, aircraft, electronics and other industries to protect tubing, precision mechanical and electrical subassemblies, threads, valves and fittings from contamination or damage prior to final assembly.*

International

The Council of the European Space Research Organization has decided to construct a Space Laboratory in Noordwijk, Holland. The center is to employ 800 and will be equipped with an environment simulator. The simulator will be built by a consortium consisting of SOGEV (a subsidiary of Compagnie Francaise Thomson-Houston) and Associated Electrical Industries in participation with British Oxygen and Heraens GmbH of Germany. . . . *Standard Telephone and Cables Ltd., British subsidiary of International Telephone and Telegraph Corp., has formed a new division to market and expand its interest in advanced on-line real-time record communication message switching systems and other computer-based system applications. ST&L is headquartered in London.*

New Activities

A new electro-optical company, h nu systems, inc., has been formed by Energy Systems, Inc., Palo Alto, Calif., as an outgrowth of ES's Optical Systems Div. The move makes h nu systems an autonomous subsidiary. . . . *Industry Diversity Institute has been formed in Northridge, Calif., to provide diversification assistance to a pilot group of defense subcontractors in Southern California. IDI is described as proposing "to meet the need for a three-part market place where new product ideas, companies wishing to diversify, and new venture capital are evaluated for compatibility. . . ." The board of trustees is composed of Southern California community leaders and business men serving voluntarily.* . . . The Jet Propulsion Laboratory of the California Institute of Technology has formed a new division, Project Engineering, under the office of JPL's assistant director for lunar and planetary projects. The division will be made up of four major sections—Launch Vehicle Integration, System Design and Integration, System Test, and Launch Operation and Environmental Requirements. . . . *Aero Geo Astro Corp., Alexandria, Va., space instrumentation firm, has changed its name to Keltec Industries, Inc.*

Missile/Space Facilities

The Navy has taken delivery on a 60-ft.-dia. antenna at Rosemont, Minn., which will be used to feed information to a navigation satellite. Electronic Specialty Co. of Los Angeles was program manager for the antenna site, which includes a 40-kw VHF transmitter, a data-reduction center, a self-contained diesel power plant and living quarters for operating personnel. . . . *Westinghouse Electric Corp.'s Defense and Space Center is building a standards laboratory near its defense and space complex at Baltimore's Friendship Airport. The facility will be built underground to eliminate vibration and radio interference and to provide the temperature stabilization required for calibration of standards for the defense and space industries. The lab will provide 10,500 sq. ft. of working space and will employ 30 persons. Construction is to begin in early 1965 and be completed in approximately one year.* . . . American Cryogenics, Inc., has announced plans to build a new air separation plant at Savannah, Ga. The facility is to produce approximately 400 tons of liquid and gaseous oxygen, nitrogen and argon a day.

Company Representatives

Ack Semiconductors, Inc., Orlando, Fla., has been appointed to distribute the Texas Instruments line of semiconductors, resistors and capacitors. . . . *Owen-Richards Co., Inc., Birmingham, Ala., has been appointed a distributor for the hydraulic-pneumatic products line of Liquidonics, Inc., Westbury, N.Y. O-R will service Georgia, Florida, Alabama and Mississippi.* . . . Manufacturing Associates, Santa Monica, Calif., has been appointed California, Arizona and Nevada representative for Washington Aluminum Co., Inc., of Baltimore, Md., and Enterprise, Ala. WAC makes large waveguides and associated components, radar antennas, radio telescopes and related structures.

AWARDS

AIR FORCE

$5,000,000—**Philco Corp.,** Western Development Laboratories, Palo Alto, Calif., for classified work.

$4,259,373—**United Aircraft Corp.,** Corporate Systems Center, Farmington, Conn., to continue work on the 433L weather observing and forecasting system.

$3,050,000—**Thompson Ramo Wooldridge, Inc.,** Space Technology Laboratories, Redondo Beach, Calif., for space-ground communications work.

$2,402,300—**FMA, Inc.,** Los Angeles, for document data-handling equipment.

$1,600,000—**North American Aviation, Inc.,** Anaheim, Calif., for continued work on *Minuteman* guidance and control equipment.

$1,575,295—**Lockheed Aircraft Co.,** Sunnyvale, Calif., for continued work on re-entry systems.

$1,500,000—**General Electric Co.,** Philadelphia, for continued work on a ballistic missile re-entry penetration study.

$1,494,714—**General Dynamics Corp.,** Fort Worth, for operation and maintenance of a radar site at Holloman AFB, Alamagordo, N.M.

$1,275,000—**Cook Electric Co.,** Tech-Center Div. Morton Grove, Ill., for development and production of new type direction-finding system units.

$1,100,000—**International Telephone and Telegraph Corp.,** Kellogg Communications Systems, Chicago, to supply transistorized communications equipment for the Missile Technical Operations Communications System (MITOC) at the Eastern Test Range; and design, supply, install, test, operate and maintain a telemetry checkout system at Vandenberg Air Force Base, Calif.

$1,032,421—**Lockheed Aircraft Co.,** Marietta, Ga., for modification of *Hound Dog* missiles.

$1,000,000—**North American Aviation, Inc.,** Canoga Park, Calif., for continued production of *Atlas* engines.

$279,000—**Douglas Aircraft Co.,** Missile & Space Systems Div., Santa Monica, Calif., for engineering services to support analysis of data and development of evaluation procedures in support of Program 437.

The Bunker-Ramo Corp., Defense Systems Div., Canoga Park, Calif., for development of machine translation of languages at the Rome Air Development Center (amount undisclosed).

Thiokol Chemical Corp., Reaction Motors Div., Denvill, N.J., for a six-month study program to analyze and determine rocket propulsion requirements for future air-launched weapons (amount undisclosed).

ARMY

$23,206,535—**Bendix Corp.,** Teterboro, N.J., for guidance and control equipment for *Pershing* missiles.

$14,845,498—**Hercules Powder Co.,** Wilmington, Del., for continued work on propellants for *Nike* and *Honest John* missiles.

$9,300,000—**Martin Co.,** Baltimore, to cover production of *Pershing* missiles during the next fiscal year.

$7,515,212—**Ford Motor Co.,** Dearborn, Mich., for continued work on *Shillelagh* anti-tank missiles.

$7,500,000—**Philco Corp.,** Aeronutronic Div., Newport Beach, Calif., increment to a previously awarded cost-plus-incentive-fee contract for continued research and development of the *Shillelagh* guided missile.

$4,659,000—**Raytheon Co.,** Lexington, Mass., for work on *Hawk* missile.

$3,900,000—**General Dynamics Corp.,** Pomona Div., Pomona, Calif., for engineering services to support production of the *Redeye* missile system.

$3,215,000—**General Telephone & Electronics Corp.,** Sylvania Electric Products Div., Mountain View, Calif., for unspecified electronics research.

$1,946,000—**Rohm & Haas,** Huntsville, Ala., for work on solid and hybrid rocket propellants.

$1,500,000—**Sperry Rand Corp.,** St. Paul, Minn., for communications systems.

$1,180,207—**Raytheon Co.,** Lexington, Mass., for work on the *Hawk* air defense missile system.

$463,000—**Hayes International Corp.,** Birmingham, Ala., for *Pershing* missile trainer program.

$99,000—**Hayes International Corp.,** Birmingham, Ala., for TA-8 Towbee targets.

NAVY

$3,087,236—**Lockheed Aircraft Co.,** Missiles & Space Co., Sunnyvale, Calif., for repair of *Polaris* missile equipment.

$3,000,000—**The Bendix Corp.,** South Bend, Ind., for continued work on the *Talos* missile.

$67,883—**Northrop Corp.,** Ventura Div., Newbury Park, Calif., for target drones and spares.

NASA

$1,568,231—**Westinghouse Electric Corp.,** Sunnyvale, Calif., for fabrication, installation and checkout of radiation shields on ETS-1 at Nuclear Rocket Development Station, Jackass Flats, Nev.

$327,138—**Cutler-Hammer, Inc.,** Airborne Instruments Lab Div., Deer Park, N.Y., for low-noise high-gain RF preamplifier.

$818,000—**Hayes International Corp.,** Birmingham, Ala., for engineering, manufacturing and related services at Huntsville, Ala.

$159,000—**Hayes International Corp.,** Birmingham, Ala., for *Saturn V* air bearing supply. Also $267,000 for development of high-pressure pneumatic piping.

$158,470—**Ling-Temco-Vought, Inc.,** Electronics Div., Anaheim, Calif., for a thruster system.

$115,733—**Electro Mechanical Research,** Princeton, N.J., for photon scintillators photomultipliers.

$70,000—**Varian Associates,** Palo Alto, Calif., for ultra-high vacuum system.

$68,000—**Aerospace Controls Corp.,** Los Angeles, Calif., for an accurate colimated solar simulator.

$64,000—**Massachusetts Institute of Technology,** Cambridge, for back-up experiment for *OAO-A*.

$48,235—**Space-General Corp.,** El Monte, Calif., for *Aerobee 150* sounding rocket roll lock-in study.

$39,744—**Whirlpool Corp., Systems Div.,** St. Joseph, Mich., for space food packaging.

$32,300—**Lockheed Aircraft Corp.,** Sunnyvale, Calif., for *Aerobee 150A* sounding rocket roll lock-in study.

INDUSTRY

$4,000,000—**Honeywell, Inc.,** St. Petersburg, Fla., from **North American Aviation,** Autonetics Div., Anaheim, Calif., for production of accelerometers for *Minuteman II* guidance system.

$750,000—**Amphenol-Borg Electronics Corp.,** Amphenol Space & Missile Systems Div., Chatsworth, Calif., from **North American Aviation,** Autonetics Div., Anaheim, Calif., for delivery through 1965 of 75 sets of stretch cable harnesses for the *Minuteman II* program.

$160,000—**ACF Industries, Inc.,** Electronics Div., Riverdale, Md., from **Lockheed Missiles and Space Co.,** Sunnyvale, Calif., for a visual display system for incorporation in a space travel simulation facility.

Sunstrand Corp., Denver, Colo., from **Westinghouse Corp.,** Underseas Div., Pittsburgh, to develop a propulsion system for the ASW *Mark 48* (amount undisclosed).

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NOVEMBER

Management Guide to Numerical Control, a seminar sponsored by the Numerical Control Society, The Summit Hotel, New York City, Nov. 12-13.

Third International Symposium on Bioastronautics and the Exploration of Space, sponsored by the Aerospace Medical Div., Air Force Systems Command, Brooks AFB, Tex., Nov. 16-18.

Conference on Ground Testing in Simulated Space Environment, sponsored by the AIAA, Huntington-Sheraton Hotel, Pasadena, Calif., Nov. 16-18.

Annual Meeting of the Association of the U.S. Army, Sheraton Park Hotel, Washington, D.C., Nov. 16-18.

Tenth Conference on Magnetism and Magnetic Materials, sponsored by the IEEE and the American Institute of Physics, Minneapolis, Minn., Nov. 16-19.

Symposium on Microelectronics and Large Systems, sponsored by the Office of Naval Research and the Univac Div. of Sperry Rand Corp., Dept. of Interior Auditorium, Washington, D.C., Nov. 17-18.

Seventh Hypervelocity Impact Symposium, sponsored by the Army, Navy, and Air Force (Secret Clearance and need-to-know certification required for attendance), Tampa, Fla., Nov. 17-19.

Tenth Anniversary Tri-Service Conference on Electromagnetic Compatibility, sponsored by IIT Research Institute, Museum of Science and Industry, Chicago, Nov. 17-19.

Northeastern States Navy Research and Development Clinic, sponsored by The Franklin Institute, Philco Corp., Temple University, the University of Pennsylvania, the Office of Naval Material, the National Security Industrial Association, and others, Philadelphia, Nov. 18-20.

Sixteenth Annual MAECON Technical Meeting, Continental Hotel, Kansas City, Mo., Nov. 23-24.

Winter Annual Meeting of the American Society of Mechanical Engineers, Statler Hilton Hotel, New York City, Nov. 29-Dec. 4.

Joint Meeting of the American Nuclear Society and Atom Fair, Hilton and St. Francis Hotels, San Francisco, Nov. 30-Dec. 3.

DECEMBER

Third Conference on Performance of High-Temperature Systems, Huntington-Sheraton Hotel, Pasadena, Calif., Dec. 7-9.

131st Annual Meeting, American Association for the Advancement of Science, Boston, Dec. 26-31.

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The Aftermath

PRESIDENT JOHNSON'S massive election victory answers some significant questions for this industry. Of equal importance, however, are those defense and space problems to which the election offers no solution and to which the President must find answers in the months ahead.

The President's victory is reassurance that the manned lunar-landing program will continue at its present pace and direction. Declarations by the Republican candidate had raised the question of whether a Goldwater Administration would have shown much enthusiasm for Project *Apollo*. The Arizona Senator's references to it as a crash program showed less than a full understanding of the facts.

It can be assumed that the President, who consistently had supported the lunar program since its initiation, will be unlikely to change his view. If anything, that support will be strengthened. The firm possibility now exists that President Johnson can go down in history as the chief executive who was in office when Americans first set foot on lunar soil. He surely will not want to leave that honor to a successor, since it will be one of the outstanding accomplishments of his terms in office and one in which he played a significant role both as Vice President and President. The President also has shown himself well aware of the importance of the lunar race in this nation's international relations.

Vice President Humphrey, as chairman of the National Aeronautics and Space Council, will take on new importance in his relationship to the industry. Mr. Humphrey has not spelled out in detail his views of the space program, but he consistently has supported it in the Senate, voting against amendments which would have cut both the NASA authorizations and appropriations. Unless an unforeseen change occurs, he will be assisted in his post as space council chairman by its able and articulate executive secretary and acting chairman, Dr. Edward Welsh.

Dr. Welsh deserves recognition for his unstinting travels to speak on behalf of the space program. Hardly a week has gone by during which he has not turned up at an industry symposium, facility dedication or civic affair to explain in clear and simple terms why the people of this nation should support the national space effort.

The election has left the Senate and House space committees under the same leadership and majority. There will be some familiar faces missing when they meet again—and this is to be regretted. These committees have been among the most able and nonpartisan of the 88th Congress. The losses, particularly on the Republican side of the House Space Committee, mean the departure of some able men. It is to be hoped that their replacements will be just as dedicated to the national interest.

One sidelight of the election was its demolition of what might be called the pork-barrel myth of the space program. Heavy investment of space and defense funds in the South by the Kennedy and Johnson Administrations had been challenged as an effort to buy votes there. It is interesting to note that those Southern States which went Republican—Alabama (Marshall Space Flight Center), Georgia (Thiokol, Lockheed), Louisiana (Boeing, Chrysler), Mississippi (Mississippi Test Center) and South Carolina (*Polaris*)—have been among the notable beneficiaries of space and defense funding since 1961. The Southern allocation of space funds may have brought wider support for the program in Congress, but obviously the effect did not carry over to the Presidential election, not at least in sufficient strength to overcome the racial issue.

While the Democratic landslide can be considered as good news for the civilian space program, it holds no assurance that some of the industry's major concerns about the Dept. of Defense will be resolved. President Johnson in his victory speech went out of his way to commend the devotion of Secretary of Defense McNamara, which must have left the Secretary somewhat red-faced at the disclosure that he had failed to register and vote in the election. Mr. McNamara, brilliant as he has been on the administrative side, leaves something to be desired on the military side of his Pentagon record—as witnessed by the Bay of Pigs, his declaration over a year ago that we soon would be able to pull out of Viet Nam, the Gulf of Tonkin snafu, and the Bien Hoa fiasco in which a handful of Viet Cong guerrillas killed four Americans, wounded 72 others and damaged or destroyed 28 U.S. aircraft.

Mr. McNamara may feel that the responsibility for some of this rests with the military. We disagree. He runs the show and he is the man who has assured us that the new system makes it possible for him to handle personally and efficiently such items as the number of hospital beds at Andrews Air Force Base. If that system isn't up to the problem of preventing field commanders from lining aircraft wingtip-to-wingtip on an airfield in hostile territory, then something is wrong with it.

WE PREDICT that President Johnson and Mr. McNamara will find that the glow of enchantment which the Secretary of Defense once cast over Capitol Hill is gone, despite the Democratic landslide registered last week. Congress is no longer as impressed with Mr. McNamara's facile memory for facts and figures as it once was. Mr. McNamara's unquestioned administrative ability may save him a firm place in the new Administration lineup. But the growing animosity between the Secretary, on one side, and the military and industry, on the other, is reducing his usefulness in the Pentagon post.

Two major military decisions immediately confront the Administration. On one, the program definition go-ahead for the *Manned Orbiting Laboratory* is assured. Fate of the *Nike-X* program is less certain. Secretary McNamara believes the anti-missile system could save more than 25% of the U.S. population in an attack—which President Johnson might note is more than voted for him in his landslide victory.

William J. Coughlin

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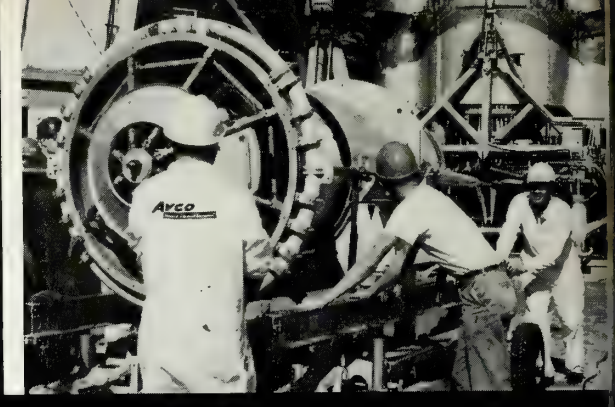
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THE WEEKLY OF SPACE SYSTEMS ENGINEERING



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Volume 15, Number 20 November 16, 1964

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Published each Monday with the exception of the last Monday in December by American Aviation Publications, Inc., 1001 Vermont Ave., N.W., Washington, D.C. 20005. Cable Address: AMERAV.

Printed at Judd & Detweiler, Inc., Washington, D.C. Second class postage paid at Washington, D.C.
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Subscription rates: U.S. and Possessions, Canada, and Pan American Postal Union Nations: 1 year, $5.00, 2 years $8.00, 3 years $10.00. All other foreign: 1 year $15.00, 2 years $25.00, 3 years $35.00. Air freight to Europe: 1 year $20.00, 2 years $30.00, 3 years $40.00. Single copy prices: regular issues 50 cents each; special issues $1.00 each. Subscriptions are solicited only from persons with identifiable commercial or professional interests in the missile/space industry. Subscription orders and changes of address should be referred to Circulation Fulfillment Mgr., Missiles and Rockets, 1001 Vermont Ave., N.W., Washington, D.C. 20005. Allow 4 weeks for change to become effective and enclose recent address label if possible.

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THE COVER

"Slug" of Sprint missile being shot from silo in test of ejection technique and mechanism. The slug, a faithful representation of the anti-missile missile except for some control surfaces, is popped 200 ft. into the air before tethers restrain it at Martin Co.'s Orlando site. Martin is Sprint developer.



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letters

Dust on Our Gideon

To the Editor:

In regard to your Oct. 12 editorial ("A Bit of a Squashy Subject"), upon reading it I immediately recalled a statement I heard or read somewhere which went, in part, like this: They say we should print a little book of rules. Whenever a government official is about to make a compromise with his conscience he should refer to the index and see if it is permissible to take a kickback for granting a government loan.

It will not work! If we are dealing with a man who does not instinctively know the difference between right and wrong, he is not going to bother to look it up in a book. It has never been necessary to alter, add to, or otherwise amend the Ten Commandments. The book is there and any crook who wants to know what it says can steal the Gideon from his hotel room and find out. We have the book but there is dust on it. The rules are plain, but there are too many of us trying to beat the game by making our own rules.

Durwood White
Huntsville, Ala.

The Gauntlet

To the Editor:

As I was reading your Oct. 19 editorial ("The Gauntlet") I was deeply shocked.

I am greatly enthused about our nation's space effort, and upon learning the facts you presented I was outraged. The distortionists should be hanged by their thumbs.

I feel without a doubt that your editorial stresses the vital fact that underlines the public's lagging to give their full support in their own nation's space endeavor. I agree strongly with your editorial, and my only hope is that this editorial will shock more people into something called patriotism.

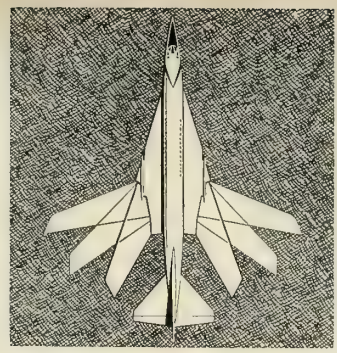
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The Countdown

WASHINGTON

No Space Czar Is Foreseen

Discount reports that the President may establish a "space czar" cabinet post to direct Dept. of Defense and NASA space programs. The White House is against it, although the idea for such a post seems to have originated with members of the official family. The plan has run into two major obstacles: Secretary of Defense McNamara and NASA Administrator Webb.

Science Academy To Push Unmanned Program

National Academy of Sciences is scheduled to release this week the full text of its position paper on future U.S. space programs, recently presented to NASA. The paper calls for a higher priority for unmanned exploration of the planets than for manned space flight. Its release is part of a push by the Academy and certain NASA space science officials for heavier funding for the *Voyager* program.

Brighter Future for Budgets

Election results may mean a small boost for the Administration in steering its NASA and DOD budgets through the House, traditionally the economy-minded body in Congress. Increased Democratic membership will make available an extra Democratic seat or two on each committee.

No Decision Reached on Titan III-X

Defense Dept. has not yet approved for development a non-manrated version of the *Titan III-A* with an *Agena* upper stage. It appears likely that Secretary McNamara will ask for further studies of this *Titan III-X* in comparison with an uprated *Atlas* standard launch vehicle.

AF Denies Titan III Move to West Coast

Air Force officials disclaim any plans to move *Titan III-A* equipment from Pad 20 at Cape Kennedy to Vandenberg AFB on the Western Test Range. Such a move was considered more than a year ago as an initial step in building up a full *Titan III* capability on the West Coast but has not been approved—although Air Force officials believe it would be a logical move.

Navy Close-Support Weapon Moves Forward

Delivery of one of the gyro packages for test flight aboard a *Sergeant* missile at White Sands moves the Navy's close-support weapon that much closer to program approval. The packages, built by Norden, were delivered to the Navy on schedule. They are expected to provide the technological base to prove to DOD the feasibility of an accurate, low-cost gyro package. This is considered an essential to program approval.

Elektrons Resemble U.S. Detection Probes

An American expert, working from unclassified sources, equates the Soviet *Elektron* series of satellites with the U.S. nuclear detection satellites. There are two satellites in widely separated orbits. The *Elektrons*, however, seem to be scientific in nature, providing synoptic readings of various parts of the radiation belts.

Titan III, Asset Launches Are Set

Titan III-A is scheduled for launch this week on the Eastern Test Range. This will be the third in the 17-flight program. Next *Asset* launch is set for December. This will be the next to last in the six-vehicle lifting body test program.

MOL $100-Million Budget Request Seen

Air Force Systems Commander Gen. Bernard A. Schriever tells COUNTDOWN that a go-ahead for the *Manned Orbiting Laboratory* will mean a $100-million FY '66 budget request. Air Force plans to move quickly into some areas of hardware development to shorten the normal program-definition time scale.

SSGS Program Future Is Uncertain

Top Air Force officials say the program to develop a Standardized Space Guidance System (SSGS) will remain an advanced technology effort for at least the next year, with no commitment for a specific hardware program. There is some debate as to whether the program should be continued at all.

INDUSTRY

Langley Asks for Ramjet Proposals

Langley Research Center is asking for proposals on a two-phase program to develop a hypersonic ramjet engine with a Mach 3-8 performance capability. Three firms will be selected for the first phase, which calls for design and development of a laboratory-size liquid hydrogen engine. Follow-on phase would result in selection of one firm for final design, development, construction and ground testing.

Marshall Services Draw 65 Bids

Marshall Space Flight Center has received 65 bids for support service contracts at 10 of its laboratories and offices. Bids resulted from more than 678 requests for proposals sent out over a six-week period beginning last Aug. 1.

INTERNATIONAL

French Show Off New Missiles

The French Army, during a recent presentation of new weapons, unveiled the new Franco-German (Nord-Boelkow) anti-tank missiles *Milan* (range 1.3 miles with infrared guidance) and *Hot* (range more than 2 miles with optical guidance and tube-launching). Also shown was the light anti-aircraft missile for which the French designation is *SABA* and which the Germans call *Roland*. This ground-to-air missile weighs more than 130 lbs. and has a range of some five miles. It is said to be effective against aircraft up to an altitude of 9,000 ft.

Australians Plan Defense Increase

In what is described as a major foreign policy shift, the Australian government has introduced into Parliament a bill calling for a 20-percent increase in defense expenditure. It also calls for a compulsory military service. Expected result is a larger Australian role in Southeast Asia defense, with particular impact on Indonesia.

DOD Budget Below $50 Billion

Defense Secretary Robert S. McNamara predicted that the Fiscal Year 1966 defense budget, including military assistance, would be held at about the current spending rate, which is running at approximately $49.8 billion. This figure, he said at a press conference after his visit to the Texas ranch of President Johnson, is about $1.25 billion less than FY '64 spending in spite of a billion-dollar military pay increase.

Emphasizing that the cuts are a result of economies within the department, McNamara claimed that military strength will increase under the new budget. The Secretary's comments were interpreted as confirmation that the overall national budget would be under $100 billion.

NASA Transfers Agena Funds

NASA has transferred $800,000 from its Lewis Research Center to the Space Systems Div. of the Air Force Systems Command for initial incremental funding of eight *Agena* launch vehicles.

Two of the vehicles produced by Lockheed Missiles & Space Co., will be used to launch the passive geodetic satellites, *PAGEOS A* and *B*. One launch is definitely scheduled; the other is a backup and presumably could be flown if necessary.

The other *Agenas* will launch the *Orbiting Geophysical Observatories B* and *E*, *Lunar Orbiters D* and *E*, and two *Advanced Technological Satellites, A* and *B*.

'Electronic AP's' Ready for Duty

An automatic security surveillance system will soon be installed at more than 100 *Atlas* and *Titan* ICBM sites throughout the U.S. by the Air Force Systems Command's Electronic Systems Div.

The 410L system operates on the doppler-radar detection technique and consists of three major components—a remote transmitter, a remote receiver and an annunciator. The system will take over the duties of more than 1,300 air policemen at the missile site underground command posts.

Mariner IV Shot in Question

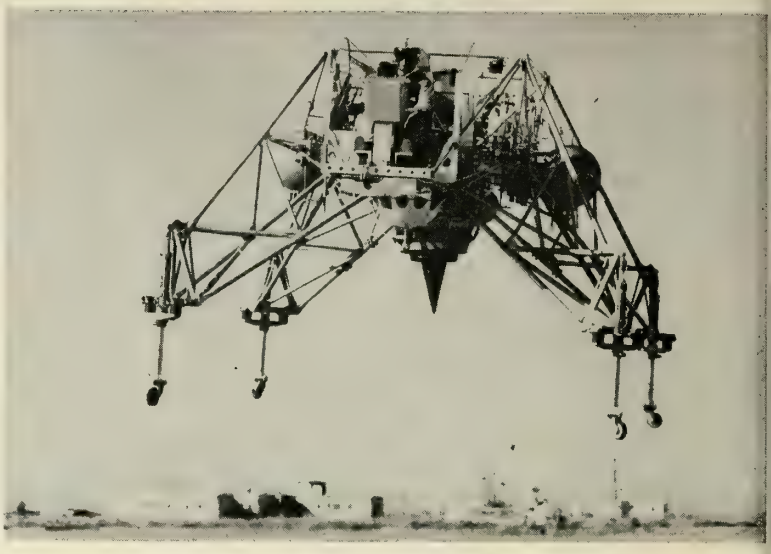
Launch of the second *Mariner* Mars probe is scheduled for Nov. 17 at the earliest, but will probably slip to Nov. 20 or 21, NASA officials predict.

Scientists met at the Cape late last week for further investigation into the failure of the first probe, *Mariner III*, launched Nov. 5 from the Cape.

NASA officials believed, however, that detailed analysis of data from the previous shot might focus attention on the shroud jettison mechanism, suspected cause of the *Mariner III* failure less than 10 hours after launch.

First sign of trouble came about 42.5 minutes after lift-off when the solar panels of the spacecraft failed to deploy. Sun acquisition was never accomplished although 17 emergency signals were sent. Though the failure is still a mystery, JPL scientists feel that a likely explanation is that the spacecraft shroud, on being jettisoned, did not clear the probe and may have damaged it.

Last contact with the spacecraft was recorded at Johannesburg, South Africa, when *Mariner* was some 76,000 miles out. Telemetry had continued to indicate a steady power drop. Shortly before transmission stopped, the spacecraft was sent a stored command to fire the midcourse correction engine. As far as can be determined, this was not accomplished.



First Flight of LLRV Announced

NASA PROJECT PILOT Joseph A. Walker is shown aloft in first flight of Flight Research Center's Lunar Landing Research Vehicle. Walker told those attending the recent Third Annual Manned Space Flight Meeting, Houston, that he took the bug-like vehicle on its maiden journey Oct. 30 at Edwards, Calif. Program is in support of Project Apollo, and the LLRV was built for NASA by Bell Aerosystems, Buffalo, N.Y. Total free-flight time on first test was just less than a minute, with the vehicle rising 10 ft.

Mercury Monument Dedicated

A monument in tribute "to the men and women who contributed to the success of Project *Mercury*" was dedicated Nov. 10 at Cape Kennedy. Dr. Edward C. Welsh, executive secretary of the National Aeronautics and Space Council, officiated at the ceremony.

Site of the monument is Launch Complex 14, used for the four *Mercury* orbital flights in 1962 and 1963.

Philco Gets Shillelagh Pact

A $20.6-million contract for mass production of the *Shillelagh* anti-tank missile has been awarded Philco Corp.'s Aeronutronic Div. by the U.S. Army Materiel Command.

The award covers plant activation, certain tooling costs and initial production of missiles and guidance and control equipment.

Aeronutronic General Manager John B. Lawson said that the divi-

sion will soon begin activation of a government-owned plant in Lawndale, Calif., for the missile and equipment production.

HIBEX Test Successful

Successful static test of the high-acceleration motor for *HIBEX* paves the way for the start of flight tests at White Sands Missile Range, N.M., later this year. All major test objectives were met, Defense officials report. The test was conducted at the Hercules Powder plant near Cumberland, Md. Hercules is propulsion contractor to Boeing for the *HIBEX* vehicle.

HIBEX is an experimental program expected to lead to a high-acceleration missile for defense of hard sites, such as ICBM emplacements, against ICBM warheads. Ten flight tests are planned in the experimental program which is to be concluded by mid-1965.

ComSat Gets RFP Replies

Six firms have replied to the Communications Satellite Corp.'s request for proposals on ground terminal stations for the global communications system. (M/R, Oct. 26, p. 10).

Summary proposals to provide research data and consultant services for the design and performance of the stations were received from: American Telephone & Telegraph Co.; ARCS Industries, Inc.; Daniel, Mann, Johnson & Mendenhall; Hughes Aircraft Co.; Page Communications Engineers, Inc.; and Westinghouse Electric Corp. One or more of the firms will be selected for the work. Winners will be restricted from providing equipment for construction of the stations.

The ComSat action would indicate that the corporation expects a favorable ruling from the Federal Communications Commission on operation and control of the initial ground stations (M/R, Nov. 2, p. 8). Some action by the FCC is expected within the next few weeks.

Shots of the Week

Athena on Nov. 7 achieved its first success in four launchings (see p. 32) while the *Mariner III* Mars probe launched two days earlier was given up as a failure when the craft's shroud apparently failed to clear the probe (see item, p. 8). The *Athena* shot was from Green River, Utah; *Mariner III*, from Cape Kennedy.

- The Air Force on Nov. 5 successfully launched the fourth *Minuteman* ICBM in as many days from Vandenberg AFB, Calif.
- An Air Force crew from McConnell AFB, Kans., successfully launched a *Titan II* ICBM from Vandenberg AFB, Calif., on Nov. 4.
- A Malmstrom AFB, Mont., crew launched a *Minuteman* from Vandenberg AFB, Calif., Nov. 9.

DOD Officials Departing

Two top-level Pentagon officials are expected to leave their posts in the election aftermath.

One of the first to depart will probably be Thomas D. Morris, Assistant Defense Secretary (Installations and Logistics), who had extended his planned length of service at Sec. McNamara's request. Expected replacement will be Army Under Secretary Paul R. Ignatius.

Paul B. Fay, Jr., Under Secretary of the Navy, is also predicted to leave the Pentagon—possibly before the end of the year. His replacement will probably be Kenneth E. BeLieu, Assistant Secretary of the Navy (Installations and Logistics).



Circle No. 2 on Subscriber Service Card

ERC To Let 35-40 Contracts

First requests for proposals go to industry Nov. 18; $2 million total is spread thinly over center's major laboratory sections

by Michael Getler

BOSTON—NASA's newly created Electronics Research Center will issue between 35 and 40 contracts, averaging about $50,000 each for a total of $2 million, within the next four months.

The center's burst of initial activity will include funded studies in each of the 10 major laboratory sections into which the Center's work is divided. Most of the contracts are expected to run for one year.

The intent, ERC Deputy Director Dr. Albert J. Kelley told MISSILES AND ROCKETS, is to get work started in each major area, even though at relatively low funding levels, so that increased activity can follow quickly in FY '66 in a number of key technical areas when the Center's budget, staff and facilities will be considerably expanded.

Kelley said the technique of spreading early funding thinly across the board to get things moving worked well in the days when the Washington-based electronics and control section of NASA's Office of Advanced Research and Technology was just getting under way.

ERC has already advertised its intention to issue its first requests for proposals for a study to aid in development of future interplanetary guidance and navigation systems. ERC officials told M/R that RFP's on this first ERC award should go to industry Nov. 18.

● **Initial contracting scope**—Within the total number of awards to be let in the second and third quarters of this fiscal year, these are the key areas, listed roughly in order of their priority:

Components—ERC will look at a host of devices specifically designed for space use. Contracts are expected in the study of new high-temperature active devices, including the so-called "amorphous" materials that can operate in extremely high temperatures without losing the desired electrical properties.

Also in this area, contracts are expected for new research in thin-film circuits, particularly active devices, and in studies of interconnection and packaging problems associated with microelectronics.

Qualification and Standards—Several different contracts will be let in this area covering techniques for selection of proven electric devices for space application, the techniques by which components can be qualified and standardized by type, and new testing and statistical correlation methods.

ERC work in this area will be tied closely to NASA Headquarters' new Parts Steering Committee and to the Office of Reliability and Quality Assurance. The aim is to develop standard specifications for space-qualified components within the next few years.

Guidance—ERC will issue studies in the area of sensitive low-level accelerometers, attempting to broadly survey an area in which many firms are working and many approaches are being pursued.

The Center is also expected to support continuing research on the newer unconventional sensors such as laser

10 Expected To Bid on AEC Work

SEVERAL missile/space firms are expected to respond to requests for proposals that have been issued by the Atomic Energy Commission for operating its production reactors and fuel fabrication facilities at Hanford, Wash.

Fourteen companies have been invited to bid, and 10 are believed ready to respond, including Douglas Aircraft Co., Aerojet-General Nucleonics, The Martin Co. and Westinghouse Electric Corp.

Others invited to submit bids by the Nov. 30 deadline were Allis-Chalmers, American Machine & Foundry Co., The Dow Chemical Co., The Firestone Tire & Rubber Co., Kaiser Industries Corp., Thompson Ramo Wooldridge, Inc., United Nuclear Corp., and U.S. Steel Corp.

Reactor and fuel-fabrication work is expected by AEC to be a $30-million-a-year operation by 1966, with total employment figured at 1,800 by July, 1966. Employment by mid-1967, however, is expected to drop 2,000 below its present level because three reactors will be shut down at Hanford.

Partly because of this, one of the major yardsticks AEC will use in contractor selection will be the amount of company funds a firm may be interested in investing in the area. Several bidders see this competition as an opportunity to expand and diversify.

Douglas has indicated that if selected, it will spend $2-3 million on a new laboratory, while Aerojet-General, in outlining its plans should it be selected as contractor, said it has already picked a management team for the operation. It would be headed by G. A. Linenburger, vice president and manager of Aerojet's Nucleonics Div.

gyros, electrostatic and cryogenic gyros, and nuclear resonance sensors, in addition to contracts concerned with methods to test some of these instruments. Of particular concern is the requirement to test low-level accelerometers down to g-levels below 10^{-3} cm/sec^2 (equal to 10^{-6} g) to perhaps 10^{-6} cm/sec^2.

ERC will also fund studies of guidance systems simplification possibilities, not necessarily associated with particular missions, but rather some across-the-board improvements, such as alternatives associated with on-board storage versus on-board computation, use of manual sextants, and re-study of the mathematics associated with setting up the guidance frame of reference.

Control—ERC will issue a contract in the area of artificial intelligence application to spacecraft control. These techniques differ from adaptive approaches in that the artificial systems will set up their own optimum operating conditions.

Microwaves—Within this lab, contracts will be put out on the sub-millimeter portion of the spectrum, reflecting a major interest by ERC in this region. Awards also will be made in the area of near-field radar propagation measurements, particularly those associated with the rendezvous docking mode.

Space Optics—Most significant new study here will be one directed at the effect of the radiation environment on various laser systems, and another on optical waveguide designs.

Instrumentation—A key effort in this area will be related to the emphasis on the sub-millimeter field. ERC will support new work in development of techniques for measuring radiated power in the sub-millimeter region.

● **Assuming OART work**—Some of this year's contract effort at ERC actually represents renewals of programs started by OART's Electronics and Control directorate in NASA Headquarters. The Washington-based ERC operation will be getting out of the industrial contracting business entirely as ERC begins to function.

The Washington office will concentrate on administering research grants to universities. ERC will also do business with the universities, but primarily on a contract basis, with a specific work statement rather than through grants. ERC also will serve as a technical monitor of some of the university grant research.

Though the ERC study on interplanetary guidance does not appear at the top of the priority list, it was ready first and will be the first one out of the Center. The contract, however, could become one of the most attractive guidance studies dispensed to industry, and the response to the original request for R&D sources has been very heavy.

A single contractor will be selected from those competing.

● **Mathematical model needed**—The primary objective of the award will be to develop an analytical mathematical model that will enable ERC to pursue a directed program of research in systems suitable for interplanetary missions. The contractor will develop the model by surveying the broad field of guidance and navigation systems, choosing a representative set of missions and the guidance functions required for them.

Once the model is developed, the contractor can take particular guidance systems, exercise them with the model to see what type of missions they can perform, and then recommend to NASA specific research programs that should be undertaken to insure that the state of the art is available to satisfy these mission demands.

Results of the study will be made available to industry, according to NASA officials here.

NASA scientists say most of the effort similar to this undertaken thus far has been directed at defining propulsion requirements, and that the guidance and navigation field has not been analyzed in the necessary depth for these missions.

ERC interest in this contract will focus primarily on the mid-course and planetary-entry phases of guidance for both manned and unmanned vehicles.

Virtually the entire guidance effort at ERC now and in the near future will focus on the post-*Apollo* 1970-period requirements, with special emphasis on the interplanetary missions.

● **Required component performance**—Using the two key parameters of gyro drift-rate and lifetime, scientists here make these rough approximations of what will be required: for the manned missions to planetary distances, gyro drift rates limited to about 10^{-3} deg./hr. will be necessary in combination with gyro lifetimes of about 100,000 hrs. MTBF; for the unmanned missions, rates on the order of 10^{-2} deg./hr. will probably be acceptable. The research into electrostatic and laser gyros, for example, is expected to provide these types of guidance systems.

For the lunar program, scientists here say that *Apollo* technology will provide drift rates of about 10^{-1} deg./hr. and MTBF figures of about 10,000 to 20,000 hrs.

To get to the post-*Apollo* levels, particularly combining both the very low drift rates and very long lifetimes, is an "extremely tough task," scientists here admit. But they are not yet convinced that what they think will be necessary is, in fact, necessary. This is one of the primary reasons for developing the mathematical model. NASA would like first to refine its estimates of exactly what the requirements will be, and then evaluate the possible accuracy versus lifetime trade-offs. ■

Better R&D Distribution Urged

Far-reaching moves have been recommended by a Congressional committee to equalize the national distribution of federal research and development funds.

The House Science and Astronautics Committee subcommittee on science, research and development says it has found that the situation is now severe enough to warrant remedial action by the government.

Major R&D agencies that voiced their feelings to the subcommittee made it quite clear they are opposed to any radical interference in their contracting placements.

However, the plan the committee suggested is geared to future R&D programs, which would not be tied to existing resources.

Perhaps the strongest of the recommendations contained in the subcommittee report were those calling for additional funds to be included in the National Science Foundation budget to insure the existence of at least one major center of excellence in research and technology in each appropriate region of the nation, and for the Defense Dept. and NASA to place emphasis on building new centers of science and technology when obsolescence of existing facilities in research-concentrated areas is revealed.

The group, which is chaired by Rep. Emilio Q. Daddario (D-Conn.), called for the White House to convene at the earliest feasible time a government-industry conference to study problems. The conference was advised to explore ways and means of equalizing distribution through: 1) identification of now unused technical capability in the research-poor sections of the nation; and 2) broader and more inclusive subcontracting.

The conference should include representatives from all government agencies substantially engaged in research and all segments of industry involved or likely to be involved, the group said.

Fund Limitations Force Voyager Mars Mission Delay Until 1971

by James Trainor

THE FIRST *Voyager* mission to Mars is now scheduled for 1971. NASA has reluctantly decided to forego the 1969 launch window, as it did the 1966 opportunity, because of funding limitations.

This means that with the exception of *Mariner IV*, planned for launch this week, the United States has withdrawn from unmanned planetary exploration until the more capable *Voyager* spacecraft is available.

At the same time, NASA officials admit that by 1971, the Soviets may have launched 30 spacecraft as against four for the U.S.

Unmanned planetary exploration is an area in which the U.S. has consistently lagged behind the Soviets.

As Dr. Charles S. Sheldon II of the Space Council points out elsewhere in this issue (p. 15), the Soviet effort is five to six times the U.S. effort. So far the U.S. has been "saved" by Soviet technical problems in the areas of launching from orbit and spacecraft reliability, but once these are solved, Sheldon says, a wide range of lunar and planetary missions of "considerable sophistication" are likely to occur.

Another Administration official told MISSILES AND ROCKETS that the Soviets have launched two, and sometimes three, unmanned planetary spacecraft during each launch window—and there is no indication that they have abandoned this practice.

● **For want of a nail**—All current NASA planning, including the preparation of the contractors' work statement and the procurement plan, are geared to provide spacecraft for the 1969 launch window. In fact, "there is the possibility of a very significant procurement in the near future," according to one NASA source. By mid-December or Jan. 1, the space agency plans to proceed with Phase 1 preliminary design competition procurement for the *Voyager* spacecraft. A program approval document has been signed by Associate Administrator Dr. Robert Seamans, and the funds are included in the Fiscal Year 1966 budget.

But the funds earmarked for the program in the '66 budget submission —now under consideration by the Bureau of the Budget—would not support a 1969 misison. What this means, M/R was told, is that the planning predicated on the 1969 misison would still be followed, but the Phase 1 effort and subsequent development would be stretched out to conform to the lower funding and the concomitant 1971 launch schedule.

For an estimated $20 million increase in *Voyager* funding, the space agency could conduct a worthwhile Mars fly-by mission, using *Voyager* components and an *Atlas/Centaur* launch vehicle. Instrumentation for this mission would probably be that proposed for the 1966 mission by a special "tiger team" of young, dynamic scientists at the Jet Propulsion Laboratory.

By increasing *Voyager* funding by $50 million, NASA would be able to launch a much heavier and more representative spacecraft using the three-stage *Saturn 1B/Centaur*. This would be essentially a *Voyager* test flight and would pave the way to take maximum advantage of the 1971 launch window—the best opportunity for the mission in the 15-year Mars-Earth synodic period.

● **Ball game still not over**—Just six months ago, the space agency had planned to perform the 1969 Mars mission with the *Atlas/Centaur* with an overlapping in 1971 with the *Saturn 1B*. However, about a month and a half ago, when the agency began seriously working on the budget, it became apparent that this plan required "a new start" in 1966 with quite a bit of additional funding involved.

Since the agency feels it has reached the budgetary plateau Congress will support, and since NASA feels it is essential that *Apollo* hardware be exploited as rapidly as possible in regular, scheduled lunar flights and long-duration Earth orbital missions, there was little money available for a new start.

A series of studies was conducted to determine what could be accomplished within the budgetary restraints. Various launch vehicles (*Atlas/Centaur*, Floxed *Atlas* and the *Saturn 1B/Centaur*), spacecraft (a more advanced *Mariner*, *Voyager* components, *Voyager* bus, and the bus plus "tiger team" package) and mission profiles (fly-by, orbiter and lander) were considered.

The agency decided it was more economical to go directly to *Voyager*. Equally important was the evaluation that there was more growth potential in the *Voyager-Saturn 1B/Centaur* combination.

This approach was recommended to, and approved by, NASA administrator James E. Webb.

In the cover letter submitted to the budget bureau by NASA, however, Webb strongly recommended that the funding be made available so that the space agency could conduct some sort of 1969 Mars mission. "It is the position of the agency," one official told M/R, "that this is the next mission that the agency would like to do."

The decision as to what pace should be adopted for the U.S. unmanned planetary program, therefore, now rests with the Budget Bureau, the President's scientific advisory committee, the National Academy of Sciences and the Presidential Science Adviser, Dr. Donald P. Hornig.

● **Voyager, a silver lining**—One of the bright spots in this picture is the fact that *Voyager*, in all the analyses undertaken, survived the test of whether or not the agency really wanted to do the mission. The program, until about a year and a half ago, was more a nebulous, advanced planning objective for a greater capability spacecraft beyond *Mariner*.

Voyager now has crystallized as the next step in the U. S. unmanned exploration of the planets. In fact, the *Mariner* and *Voyager* programs have been merged into a single system. This spacecraft will be designed primarily for Mars exploration, but will be adaptable to Venus missions—with some components capable of even more distant exploration.

Voyager, as presently envisaged, would weigh about 7,000 lbs. and would consist of a spacecraft bus—housing the retro-propulsion unit, the orbiter and housekeeping functions—and the lander (or landers) for studies of planetary surfaces. ■

By MSC officials . . .

Apollo-X Presentation Is First Step Toward NASA Space Station

Seamans receives plan recommending program definition in FY '66; up to 18 flights proposed from 1968-1971

by Hal Taylor

MANNED SPACE FLIGHT officials have taken the first step leading to a NASA space station program with the presentation of plans for the *Apollo-X* spacecraft to Associate Administrator Dr. Robert C. Seamans, Jr.

The plans call for the program-definition phase to be initiated in the next fiscal year, with early plans recommending as many as 18 flights in the 1968-71 period.

The presentation on *Apollo-X* was made last week.

In addition to modification work on the *Apollo* spacecraft and extending the capability of certain of its subsystems, the new project will provide many new contracts for industry because of its requirements for new scientific experimental payloads worth hundreds of millions of dollars.

For flights up to 45 days, the space for additional expendables and experiments will be provided by removing the ascent stage propulsion from the Lunar Excursion Module. For flights up to two months, two propellant tanks would be removed from the Service Module to provide the necessary space.

Apollo-X will be followed by the first true NASA space station, which will be launched in the 1972-73 period. This project is expected to go to program definition in either FY '67 or '68. It will be capable of supporting six to 12 men for more than a year.

● **Configuration debated**—There is currently some disagreement within the space agency as to just what configuration will be selected for the first space station.

Certain officials at the Manned Spacecraft Center, Houston, want to add modules or laboratories to the *Apollo* spacecraft, increasing its capability to six to nine men. Later, according to the MSC officials, three of these modules would be joined together to provide a space station capable of housing from 18-36 astronauts.

Headquarters officials, however, seriously doubt that such a large orbiting station will ever be required by the U.S. space program. They currently lean instead toward the Langley Research Center's *Manned Orbiting Research Laboratory* (*MORL*) approach, which calls for development of a new spacecraft to house its six to 12-man crew. *Apollo-X* or a regular *Apollo* spacecraft would be used as the logistic vehicle.

In discussing MSC space station research, William Stoney, chief of Advanced Spacecraft Technology and Design, said that Project *Apollo* and its associated research, development and launch vehicle systems can perform most of the work needed to qualify men and spacecraft for longer missions.

● **Space power obstacle**—Stoney said that power is the biggest roadblock to space station development. "We could try to get the necessary capability with solar cells," he said, "but this has inherent problems. The cells create extra drag and you must keep the panels pointed to the Sun. This restricts your freedom of movement. Forty kilowatts will require 2-3 million solar cells.

"The SNAP systems are interesting, but we have to understand how to shield people who will wander around outside the spacecraft. Radioisotope generators and thermionic units, marked by their high temperatures, are also possibilities. So are fuel cells because they produce water, and we will need water, but they are time limited."

He continued by observing that extended life-support systems and improved landing systems will be needed from industry.

● **Building-block approach**—Stoney said MSC is studying modules capable of being integrated into a more complex spacecraft structure. Plans call for putting the modules in space for six months or a year and testing components with the *Apollo-X*. These modules could be substituted for the LEM.

"If we have a national space station, these parts can be developed and tested singly by launching them on a *Saturn IB*, or by putting them all together and launching them on the *Saturn V*. The power section could be one module. One could also put two of the living modules on *Apollo* and launch them with the men on a *Saturn V*," he said.

He suggested that an intermediate space station, which could dock with an *Apollo*, be made. "This would be one arm of the Y-shaped space station," he said.

These modular components would allow a "large" space station to be broken down and given the same rigorous ground tests that the *Apollo* spacecraft modules will receive, Center officials said. For instance, one or more of the modular rooms, experiment capsules, or power packages could be placed in the main space chamber at MSC for simulated space missions before being launched.

Building up to a single arm of the space station will give accommodations for six to nine men while a determination is made on the larger 18 to 36-man station. Three stacks may be combined for a *Saturn V* launch of a three-armed station.

Stoney said that these *Apollo*-oriented plans do not necessarily mean a monopoly for North American and Grumman. "We'd like to find ways to use other companies and get them into the game. After all, Ford made Convair bombers during the war," he pointed out.

Stoney also proposed that the new NASA university spacecraft grants programs might encompass manned as well as unmanned payloads. Aerospace companies might work with selected universities to design, build and test experiment modules to be flown on *Apollo* missions. Astronauts and scientist-astronauts might be used to operate the experiments, he speculated, or the experimental packages could be launched with manned flights. ■

Launch Vehicle Jockeying Begins

Agreement sought on whether NASA, Air Force should develop high-energy third stage; DOD appears to favor Centaur

NASA AND the Defense Department are attempting to reach agreement on which agency should develop a new third stage for the *Titan III* or the *Saturn 1B*. Meetings of the Joint NASA-DOD launch vehicle panel of the Aeronautics and Astronautics Coordinating Board have been held, and several trade-off studies ordered to provide a factual basis for an agreement.

Space agency officials, it is understood, are advocating use of *Centaur* as the high-energy upper stage for both vehicles, while the Air Force is pressing for development of a completely new high-energy liquid fluorine engine. The Defense Department appears to be leaning toward the NASA position on the basis of greater cost/effectiveness.

Air Force contention is that there is no point in uprating a stage (*Centaur*) that has limited growth potential at best. It would be more advantageous and be a more effective use of the funds to develop a new technology (fluorine) with an untapped growth potential.

● **Crucial decision**—In addition to the availability of *Centaur* vs. development of a new engine, NASA forsees the decision as indicative of which booster will be used extensively for advanced lunar and planetary missions. The Air Force, if allowed to develop the engine, would have a more persuasive argument for use of the *Titan III* in NASA programs.

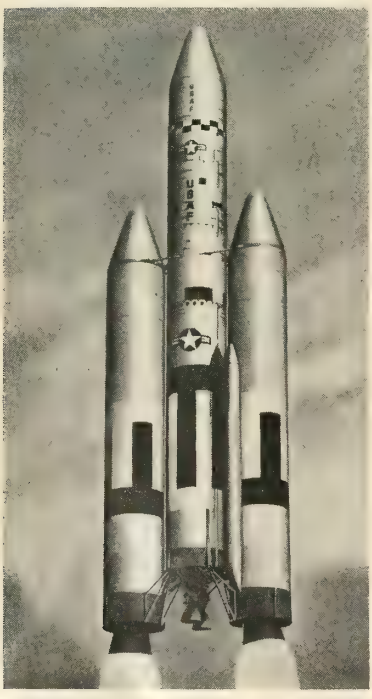
The *Saturn 1B* has no capability to launch payloads on escape missions. The *Titan III-C*, with the present transtage, could boost 5,000 lbs. to escape. With *Centaur* added to the *1B*, officials estimate that its escape payload would be adequate to send 7,000-9,000 lbs. to the near planets—Mars and Venus. An additional advantage of the *1B* is that the payload size is not as constrained as it would be in the *Titan III-C* envelope. The entire 260-in.-dia. of the *1B* could be used by shrouding both the payload and the *Centaur*, while extending the shroud diameter in the *Titan III* beyond 120 in., would require hammerheading the vehicle.

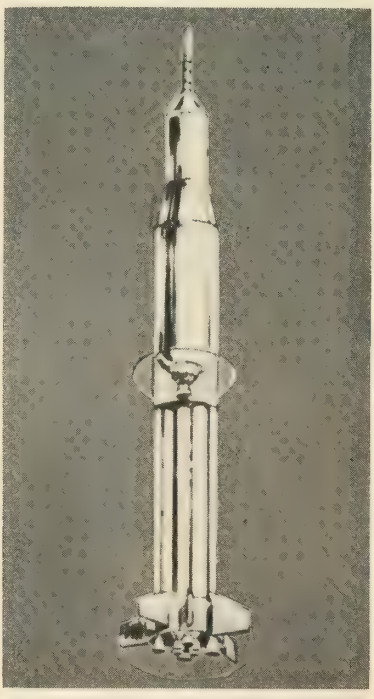
● **Pro-Titan**—Advantages of the *Titan III*, on the other hand, are the classic virtues of that vehicle: cost, reliability, versatility and rapid launch rate. But since development of both vehicles is now conceded, these are cancelled to a degree by the *1B's* ability to handle a greater variety of lunar and planetary payloads.

More than $2.5 million was earmarked in the Fiscal Year 1965 Air Force budget for definition of design criteria and performance parameters of a high-energy upper stage. This is presumably a liquid fluorine-liquid hydrogen stage based on RL-10 engine technology.

Centaur consists of two RL-10 liquid oxygen-liquid hydrogen engines developing 30,000 lbs. total thrust. Flight tests of the stage—plagued by development problems—are still being conducted, but the stage is expected to be operational in 1965.

Decision of the launch vehicle panel is expected to have to await the results of the studies. No agreement is expected before the end of this year. The launch vehicle panel is headed by Alexander Flax, Assistant Secretary of Defense (R&D) for the Air Force. NASA's chief representative is Milton Rosen, senior scientist in the agency's Office of Defense Affairs. ■





AIR FORCE Titan III (left) and NASA Saturn 1B vie for advanced missions. Space agency wants Centaur upper stage for Saturn; AF proposes all-new Titan stage.

Space Council member says . . .

Gaseous Rockets Could Re-Shape Space Transportation Principles

PARAMETRIC STUDIES of gaseous core rockets hold the promise of revolutionizing space transportation, and, if aggressively and imaginatively pursued, could make the United States "the leading spacefaring nation," an Administration official told the recent joint AIAA/NASA Third Manned Space Flight Meeting.

"Such a ship, these studies show, would be much more than marrying one of today's vehicles to a hot new power plant," Dr. Charles S. Sheldon II of the National Aeronautics and Space Council said. "It could bring us to a new generation of space transports versatile enough to use ordinary flying fields, able to maneuver in space, and with such power that travel time throughout the year to the near planets would fall to less than a week, and even the far planets would be only months away."

● **Big potential**—Quoting mission costs per pound of payload of "somewhere near" one dollar (*Saturn V* costs per pound of payload are estimated at $200-300), Sheldon asserted that by applying the current space budget to such a transportation system, the U.S. would be able to put 50,000 lbs. of supplies every year on the Moon, Mars, Venus and a "satellite or two" of the giant planets—a scale equal to the present support of the U.S. Antarctic base.

Other advanced systems suggested to revolutionize the priorities and demand for space exploration are Project Orion and controlled thermonuclear reactors.

But since work on these advanced systems is not far enough along "to convince those who control funds to keep it at much more than a sustaining level," the real spaceship is still far off. Sheldon holds forth the hope that at some time "in the relatively near future, there will be enough indicators of promise that all the review boards and administrative powers will recommend the kind of support which will carry us rapidly to practical flight hardware."

● **Soviet effort analyzed**—The paper, entitled "The Challenge of International Competition," contains a detailed deductive analysis of the Soviet space effort and proves by both the scope and volume of Soviet efforts that there is "no real sign that the Soviet Union is marking time so that we can catch up without working hard."

On the question of whether the Soviet Union is engaged in a manned lunar landing program, Sheldon concludes that "there is conclusive public evidence neither for nor against their having an urgent manned lunar landing or planetary landing program." He then draws a parallel to the *Apollo* program and the situation that would exist if the U.S. applied Soviet-style secrecy to the effort.

"Cautious foreign observers," he concludes, "would have to report there was no objective evidence that the United States is developing a manned lunar capability, in the absence of orbital flight tests of the necessary large launch vehicles."

By inference from past Soviet procedures of orbiting an unmanned spacecraft and recovering it after the number of orbits planned for the subsequent manned mission, Sheldon deduces that the *Voskhod* flight was indeed planned for only one day. *Cosmos 47,* which preceded thte manned flight, was also recovered after 16 orbits.

Voskhod, in addition to its retrosystem, which reduces the capsule to essentially zero-speed just before ground impact, tested an ion-engine attitude-control system and also carried an external television camera that permitted the crew to look aft where there were no portholes.

Best guess as to the nature of the new, more powerful carrier rocket announced by the Soviets for the *Voskhod* flight would be the heavy *Sputnik* combination used for interplanetary probes. Sheldon reasons that, since the Soviets operate their manned program in a conservative manner with careful man-rating of vehicles, a combination of tested and tried vehicle stages was used.

In February, 1961, the Soviets announced that the heavy *Sputnik* combination could put 14,300 lbs. in low Earth orbit and, at the time, said the system would be used in future manned flights.

● **Planetary program**—The total Soviet lunar and planetary program, according to Sheldon, "has been on a massive scale, far exceeding anything programmed in this country. . . ." By analyzing statements by U.S. officials that the Soviet commitment to escape missions exceeds the U.S. effort by a factor of four, both in absolute numbers and in proportion to the total effort, he shows that Soviet escape missions range from a possible 20 to 24 spacecraft. Of these, the Soviet Union has had seven successful commitments to lunar and planetary flights and 10 more that are known to have failed.

The Soviet Union has made multiple attempts at each planetary window, and, in spite of numerous failures, is tenaciously continuing the practice under the *Cosmos* label, which enables them to "hide" those spacecraft that fail to launch from Earth orbit. "Once these heavy spacecraft begin to work," Sheldon warns, "one can expect lunar orbiters, lunar soft landers, and a variety of planetary experiments of considerable sophistication."

Of the *Cosmos* series, Sheldon feels these satellites give the Soviet Union "a cover" for a wide variety of space missions, such as the planetary flights, applications experiments, manned spacecraft tests, geophysical experiments and reconnaissance overflights. These can all be reported to the United Nations without the necessity of being specific. Thus, they avoid the approbation they received in September, 1962, when Ambassador Adlai Stevenson revealed to the U.N. that the Soviets had failed to list six planetary spacecraft that failed to leave Earth orbit.

● **Cosmos series dissected**—In Sheldon's analysis, the 49 *Cosmos* flights are broken down this way:

—Sixteen modest-sized, non-recoverables in 49-degree inclination orbits from Kapustin Yar, plus two more in a dual launch of the same pattern.

—Twenty large satellites of the recoverable class in 65-degree inclination orbits from thte Tyuratam area, plus three more seemingly the same, except in 51-degree inclination orbits.

—Eight from Tyuratam not fitting the regular pattern, including two in short-lived orbits from which recovery was unlikely, a triple launch at an inclination of 56 degrees, one probably large spacecraft out to 22,000 mi. from a heavy *Sputnik* launch platform, one in a moderate circular orbit "at a height good for weather, navigation or other observation," and the final one a rehearsal for *Voskhod.*

Sheldon strongly emphasizes that his views and analyses of the Soviet space effort are his own and the information is drawn from unclassified sources. Thus, some of the data "are incomplete and possibly inaccurate when compared with the best classified information." ■



FIVE NEW MISSILES were paraded through Moscow's Red Square last week, with Red Chinese Foreign Minister Chou En-lai looking on, to mark the 47th anniversary of the 1917 Bolshevik Revolution. Included in the display were a tactical multiple-launch rocket (left foreground), underwater-launched missile and a new, large "pilotless interceptor" (right foreground).

Soviets Display Five New Missiles In Red Square Anniversary Parade

PILOTLESS INTERCEPTORS, apparently Soviet anti-missile missiles, resemble the U.S. Nike-Zeus. Photo below shows missile to be three-stage type with "jet-head" terminal homing.



LARGE-DIAMETER rockets seen by the West for the first time were described by the Russian news agency Tass as "strategic intercontinental rockets."

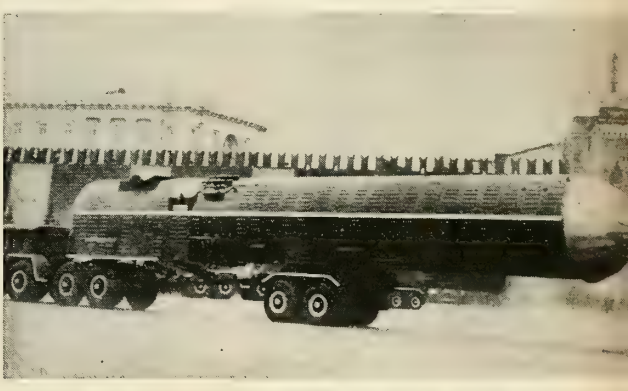


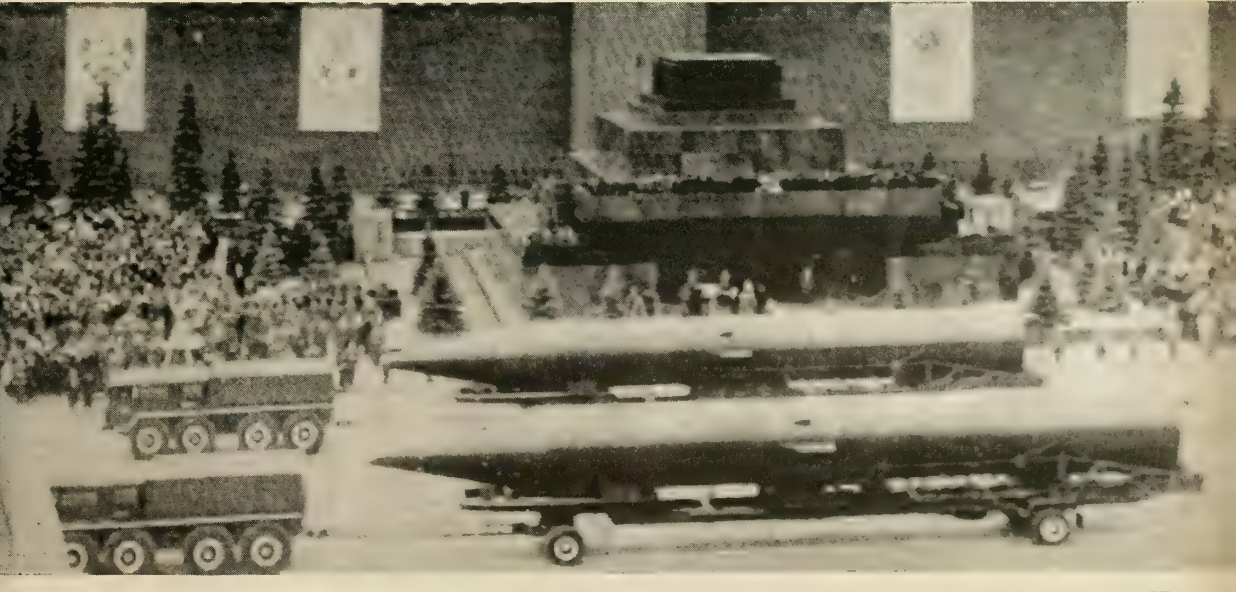


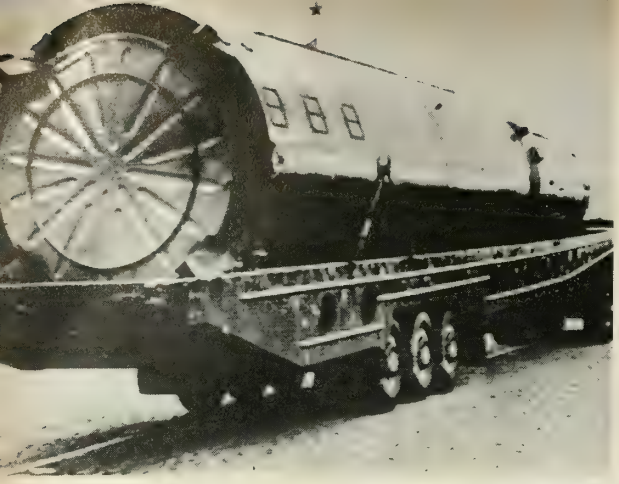


ABOVE LEFT: New "long-distance" rocket was described by western observers as being about 85-ft. long and 10 ft. in diameter. The 16-wheel transporter needed for heavy weight probably indicates that the missile is liquid-propelled. The two-stage weapon could be the missile reported under development as the storable-propellant vehicle being hardened and dispersed in underground silos. It is roughly comparable to the U.S. Titan.

ABOVE RIGHT AND RIGHT: Two views show what has been identified as another anti-missile missile, with four nozzles showing in the open end of the canister. Jacket around the missile suggests it may be necessary to condition the weapon to its environment—possibly indicating an early state of solid-propellant technology. BELOW: Missiles closely resemble the Sandal surface-to-surface weapon. Comparable to the now-retired U.S. Redstone, Sandal is about 70-ft. long and 5.6 ft. in diameter, with a 500-mi. range. It is not clear if this is the older Sandal or an improved version.

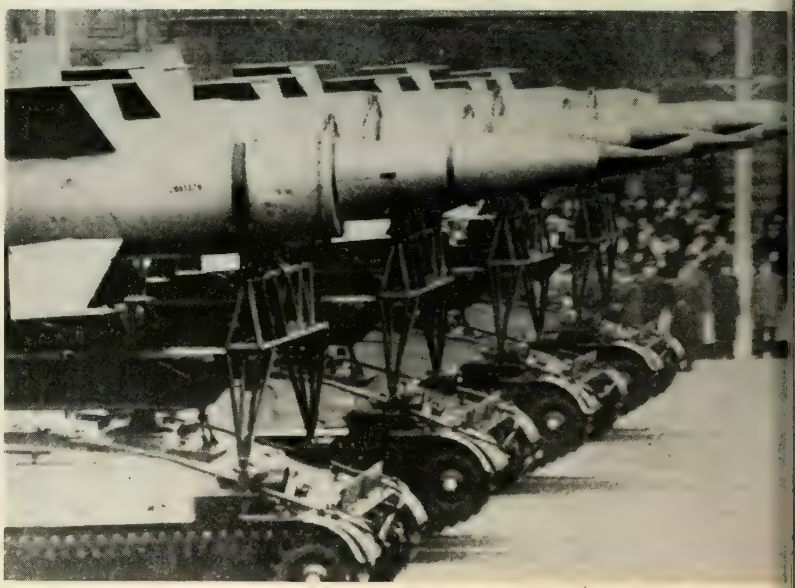


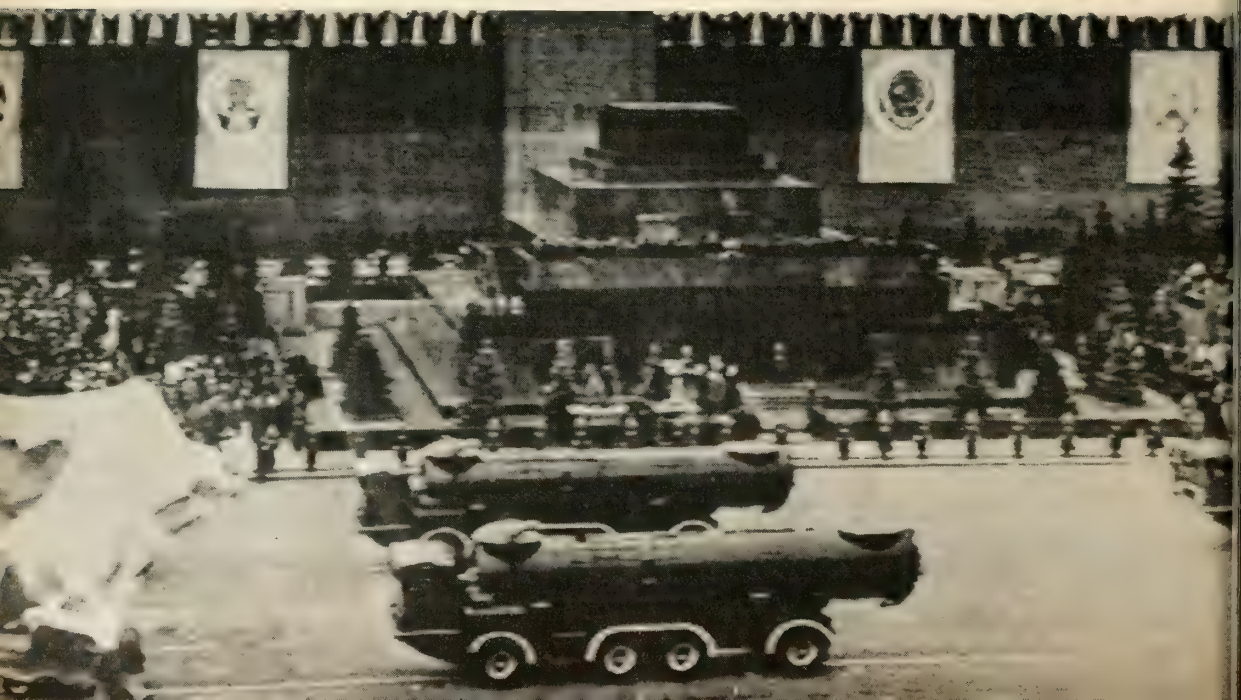






ABOVE LEFT AND RIGHT: Missile shown in two views was termed by a Soviet commentator "a younger sister" of the rocket that launched the three-man Voskhod spacecraft. The vehicle appears to be a two-stage, liquid-propelled missile. End-plate (left view) is used to protect nozzle, pneumatic and electrical parts. RIGHT: Mobile missile is shown on its tracked vehicle transporter-launcher. Missile appears to be a single-stage rocket. Supports on front of vehicle are probably used to tie the missile down during transport. BELOW: Two vehicles described as underwater-launched missiles pass Lenin's tomb. White blur at left is portion of a flag located close to camera.





Technical Countdown

ELECTRONICS

New ASE Transducer Uses Seen

A team of scientists from Raytheon's Research Div. in Waltham, Mass., reporting to The Northeast Electronics Research and Engineering Meeting on the firm's efforts in developing new microelectronic transducers which utilize the anisotropic stress effect, see a whole new range of applications for these devices if refinements can be made on some of the basic questions revolving around the effect. The basic ASE phenomenon shows that mechanical point contacts can be applied to a silicon wafer containing a junction within a micron or so of the surface, and that the current of the diode increases substantially with the application of even a few grams of force. What this means is that mechanical-to-electrical couplings can be included within a single functional electronic block, which, in turn, means that transducers and sensors could, for example, be linked with a data-processing function. Among the space applications seen by Raytheon: an accelerometer in a single package weighing about 1 gram, including the seismic mass, the sensing piezotransistor, the data-processing microcircuit, and the output transmitter-oscillator.

LFE Reports New 35-GC Paramp

A new parametric amplifier that operates at the 35-gc atmospheric window in the millimeter wave region has been developed by engineers at Laboratory for Electronics, Inc., Boston, and reported on at the recent Northeast Research and Engineering Meeting. The device, developed under AF funds from the Research and Technology Div. at Wright-Patterson AFB, Ohio, uses a unique below-signal pumping scheme. Use of two tuned-idler circuits instead of one allows the amplifier to use a below-signal pump frequency of 29 gc, and avoids the requirements for pump power sources above 100 gc, which would be needed with the more conventional single-idler approach. While the prototype amplifier is expected to be used for radiometry experiments, the same device could be used in a radar front-end for ground-to-space communications, high resolution surveillance, and radar observation of cloud cover. Interest in millimeter devices for these applications is steadily increasing (M/R, Sept. 7, p. 38).

Gyros Life Test Run Passes 2.5-Year Mark

A pair of Kearfott Inertial Navigation gyros chosen at random in mid-June, 1962, and placed on life-test have been running continuously without deviating from the original specifications. The ball bearing gyros are single-degree-of-freedom, miniature floated rate integrating units with high torquer linearity. The hermetically sealed bearings spin at 24,000 rpm in the prolonged test at General Precision's Kearfott Division, Little Falls, N. J.

LIFE SUPPORT

Space Suit Testing in High Gear

Seventeen *Gemini* space suits are undergoing vigorous testing at five locations for operational qualification. Two are undergoing the *Gemini* ejection profile in the *Gemini* seat from AF F-106 aircraft, five are being used for parachute jump tests at El Centro, Calif., and four will undergo sled ejection tests at China Lake. In addition, two are at the Manned Spacecraft Center for testing of physical parameters and four are at the U. S. Army Testing Laboratory, Matick, Mass., for life cycling and reliability tests on the suit and individual components.

MATERIALS

BTL Claims Laser Mirror Advance

Bell Telephone Laboratory scientists reported on an important advance in laser mirror reflectivity qualities at the Northeast Research and Engineering Meeting in Boston earlier this month. BTL's D. L. Perry told the audience about development of a new technique of coating a mirror blank with many layers of optically transparent diaelectric material in a way that virtually eliminates light scattering from the reflective surface. Reflectivity is so close to complete, he reports, that the amount of loss is, as yet, unmeasureable. "Broadband" mirrors have been made using this technique in the visible spectrum between 4,200 and 7,600 Angstroms, BTL reports. The BTL technique involves three basic process changes from traditional mirror coating methods. By using dielectric material in large chunks instead of in the usual powder form and evaporating them at a precise temperature just below the melting point, Perry found that the number of scatter-producing large particles deposited on the mirror was reduced. Also, BTL found that the process of glow-discharge cleaning of substrates could be eliminated through careful handling.

Al Fatigue Moisture Relationship Revealed

Researchers at the National Bureau of Standards now know that the presence of water vapor during the initial stages of alternate stressing has no effect on the fatigue strength of aluminum alloy specimens. But at the end of this initial period fatigue cracks develop and propagate more rapidly in a moist atmosphere than in a dry one. Experts at the NBS Institute for Materials Research have proposed a tentative explanation. During the initial period the metal is apparently undergoing plastic deformation on a microscopic scale, resulting in work hardening. The deformation is not large enough to break the protective oxide surface layer on the aluminum. Eventually the work hardening ends and softening begins. Then local deformation concentrations rupture the oxide film allowing water vapor to react with the aluminum.

Environmental Press Cuts Ti Forming Cost

An environmental hot press developed by American Hydrocarbon Corp. cuts the overall cost of forming titanium parts by as much as 21% over other methods. The press includes a controlled atmosphere work area housing the titanium stock—eliminating the problems of oxidation and scaling of heat-exposed parts. Titanium parts and assemblies can be formed, sized, heat-treated and stress-relieved in a single operation. The press can also be used for hot-forming toxic metals such as berryllium. The development is the result of research by the firm's subsidiaries, Basic Industries, Inc., and Intercontinental Mfg. Co. American Hydrocarbon is seeking patents on the development and the first unit should be in operation within two months.

All-Metal Diffusion Pump Practical New Route to Ultra-High Vacuums

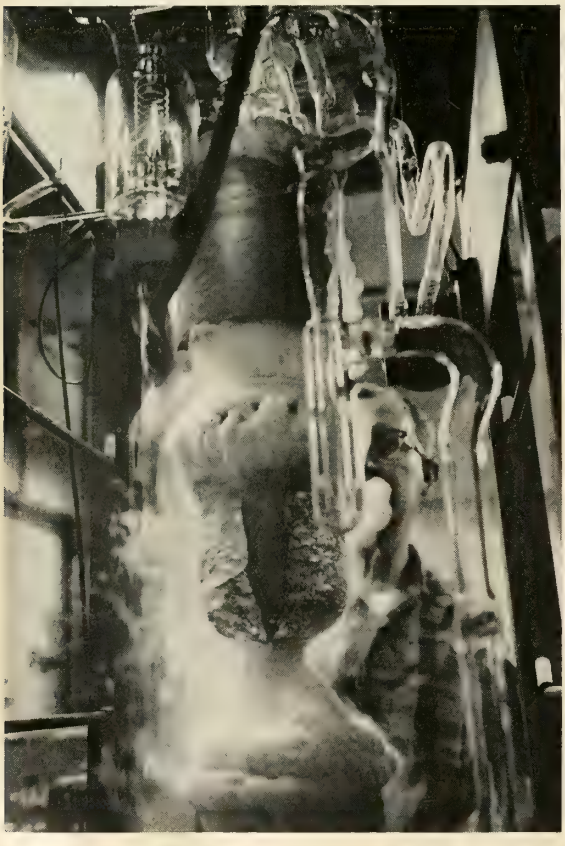
GCA scientists achieve vacuums of 10^{-13} torr with stainless steel device that operates at room temperature

by William S. Beller

BEDFORD, MASS.—Exceedingly high vacuums have been drawn by a rugged, demountable and relatively inexpensive diffusion pump system in recent demonstrations here.

The application of deep vacuums, although unanticipated for many years, today goes into fields such as plasma physics, high-voltage accelerators, vacuum metallurgy and semiconductor surfaces in addition to the obvious ones involving the simulation of the vacuum of outer space.

The emergence of a practicable diffusion pump for creating vacuums below 10^{-12} torr—such as scientists here at the Geophysics Corp. of America claim they have designed under contract to NASA—will now give engineers a third choice in picking an ultra-high vacuum system for their work. Other choices: a cyrogenic pump or a combination of a sputter-ion pump and a titanium sublimation pump.



FIRST PHOTOGRAPH of new laboratory system developed by GCA for NASA to create pressures as low as 10^{-13} torr. Intended to test or calibrate low-pressure measuring instruments for space programs, the system is similar to an all-metal one that can be assembled in modular form. Based on the mercury diffusion pump principle, this design can be scaled up to test space components under space vacuum conditions.

● **Few choices**—To reach vacuums much harder than 10^{-12} torr, engineers have a choice probably limited to either cryogenic or diffusion pump systems, A. E. Barrington, manager of GCA's Ion Physics Dept., told MISSILES AND ROCKETS.

The cryogenic pump works on the basis that at a sufficiently low temperature, a surface can pump out a volume simply by condensing onto it the gases present. In practice, liquid helium almost invariably is used to cool the walls of the chamber being evacuated. The advantage of the system is that it can pull a very low vacuum at a relatively high speed. Its disadvantage is that its operating costs are signficant because of the usual unregenerative expenditure of helium.

Another disadvantage sometimes raised is that cyrogenic pumping does not remove a gas from a system but simply freezes it on the walls. Thus, if the cryostat fails, the gases evaporate back into the system.

In the sputter-ion pump, ions are produced by bombarding gas molecules with electrons. Gases are then removed by three mechanisms: 1) the gaseous ions are adsorbed by the collector; 2) other ions dislodge and vaporize some of the electrode material—sometimes called sputtering—which, in turn, traps some of the ions when it condenses on the chamber walls; and 3) ions combine chemically with the collector material, often titanium, forming stable nongaseous compounds.

Barrington believes it is less likely that the sputter-ion pump can get the degree of vacuum of either the cyrogenic or diffusion pumps. The reason

is that eventually an equilibrium is set up between the gas being pumped and the gas being released from the electrode or collector by ion bombardment. In practice, this limiting gas pressure is due to the release of hydrogen from the electrode material.

● **An old idea**—The theory behind the GCA diffusion pump is years old. But the contribution the company made to the art is in casting the system in metal rather than in the glass devices used up to now.

A diffusion pump simply uses a directed, high-speed jet of a heavy vapor, which can be an oil or mercury, to entrain gas molecules and sweep them out through an exit in the vacuum chamber.

The disadvantages of using glass in a vacuum system are well known. Besides the material's structural fragility, glass does not withstand temperature cycling well. (Cycling is needed to drive adsorbed gas off the walls of the chamber before deep pumping begins.) Glass, moreover, is permeable to helium, which seeps in from the atmosphere, limiting the amount of vacuum that can be reached.

The GCA system is built of stainless steel; it can be taken apart and put together again with simple hand tools, the designers claim. So far, only a small chamber has been built. Based on a mercury diffusion pump, it produced pressures of 10^{-13} torr in a test chamber at room temperature without the use of liquid helium. GCA says the chamber is excellent for comparing the low-pressure characteristics of various vacuum gauges and mass spectrometers.

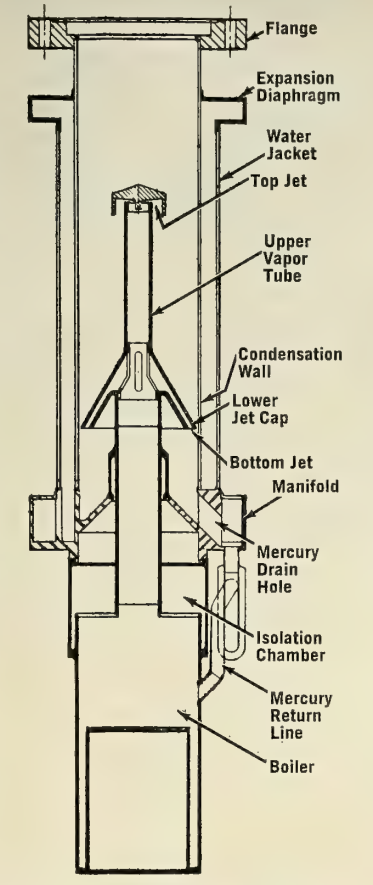
Furthermore, the system "can serve as a prototype of much larger systems that would be suitable for testing space vehicle components," said Wallace Kreisman, GCA scientist and developer of this mercury diffusion pump system. He saw no reason why one couldn't be built several times larger than its present working volume of two liters.

The system also has disadvantages. If the electrical power fails, even for a short time, the vacuum is lost. This is not necessarily true of cryogenic or ion-pump systems. In addition, the ultimate vacuum reached is limited by the diffusion of the vapor of the pumping fluid into the vacuum chamber.

Barrington pointed out that the vacuum pulled by GCA's pump may go below 10^{-13} torr, but there is as yet no accurate or reliable gauge that will reveal this (M/R, Oct. 19, p. 36).

● **Why it's different**—Key innovations in GCA's mercury diffusion pump, the central element of the system:

—The upper part of the pump, including the manifold, was baked many times at various temperatures up to a maximum of 474°C. Kreisman credits this temperature cycling for the pump's excellent performance. Were it not for this long-term baking, outgassing from the pump materials would be contributing to the gas load, thereby limiting the vacuum that could be drawn.



CROSS-SECTIONAL view of GCA's stainless steel mercury diffusion pump.

—The top jet of the pump is relatively small in diameter and shaped to emit its vapor stream in a downward direction. The spacing between the top and bottom jets is made relatively large to increase the probability of entraining gas molecules. The bottom jet, with its closer spacing and higher temperature vapor, serves to prevent back diffusion of higher pressure gas. Thus, the lower jet provides a high fore-pressure while the top jet provides a high pumping speed at low presures.

—The condensation wall (pump barrel) of the pump is kept at a uniform, low temperature by using an annular water jacket instead of the more conventional water-cooled spiral coil. An expansion diaphragm near the top of the water jacket relieves any stresses that might be created by differential expansion during the bakeout period.

—The isolation chamber, located just above the pump boiler, acts as a heat-insulator to separate the hot boiler from the cold manifold during normal operation. During the bakeout period, the isolation chamber serves to minimize heat flow from the hot manifold to the boiler. A vacuum of 10 to 20 microns is maintained in the isolation chamber by means of a direct connection to a mechanical rotary pump.

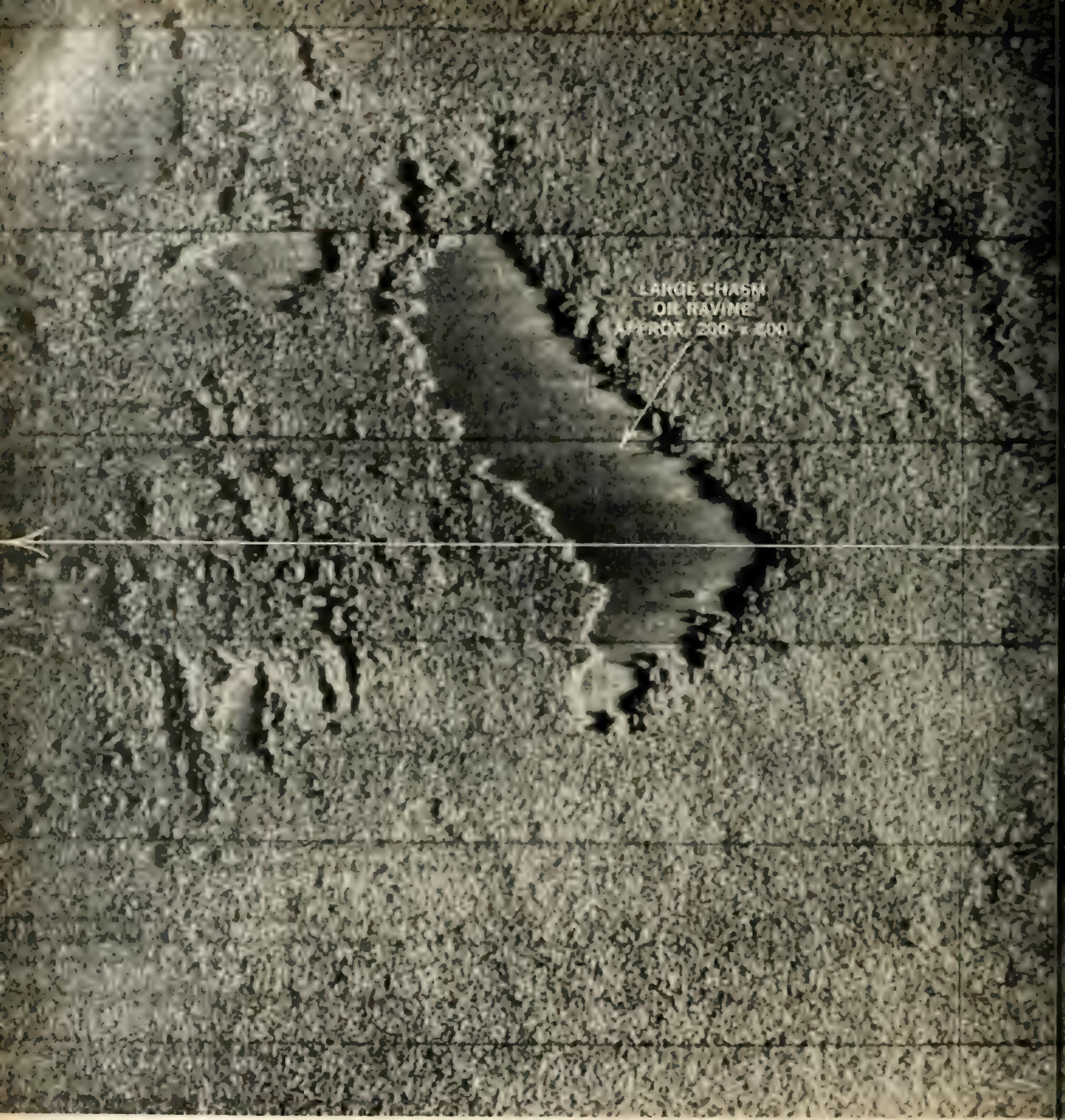
—A stainless steel, non-level-sensitive cold trap was designed so that every atom of mercury would have to make at least two collisions with a cold surface in order to pass through. On this basis, two cold traps of the new type would be equivalent to four cold traps of the old design. By reducing the number of cold traps required to eliminate back flow of the pumping fluid, 1) there are fewer components and vacuum connections, 2) the internal surface areas are reduced so that outgassing is reduced, and 3) the total vacuum conductance of the cold traps is increased.

● **Detecting leaks**—In order to assemble a vacuum system of the GCA type, it is desirable to leak-test it component by component. The most widely applied technique of leak detection uses a sensor that responds only to a particular test gas. The sensor is attached to the device to be tested, and the combination is evacuated by a vacuum pump.

The test gas is then applied externally and the sensor gives an indication when the test gas penetrates through the leak. It is desirable that the test gas be chemically inactive and not a constituent of air. Helium, which is present to the extent of only five parts per million in air, is the preferred test gas.

Helium detectors currently available can detect leak rates as small as 5×10^{-11} cubic centimeters of gas at atmospheric pressure per second—not sensitive enough for ultra-high vacuum work. However, a novel device developed this past year by GCA improves upon this figure by at least a factor of 100, according to Barrington. Compared with conventional helium-leak detectors, this one is claimed to be smaller and more rugged in addition to being burn-out proof and bakeable up to 450°C—a great advantage in many applications.

The device is described as a specially designed, inverted cold-cathode magnetron cell approximately 1 in. in diameter and with its permanent magnet weighing one pound. This is a novel use of the magnetron cell, which normally is used as an ionization pressure gauge, not as a mass spectrometer or as a leak detector. The new device costs no more to produce than conventional leak detectors, according to reports. ■



This is an actual reproduction of a high definition sonar image obtained in a continuou

New Westinghouse sonar made this image of the

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Photo courtesy Hudson Laboratories of Columbia University

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Seismic Communications Under Study

AF, RCA, Raytheon approaches to propagation through Earth's crust detailed at NEREM; R&D spending seen holding steady

BOSTON—Use of a variety of electronic and seismic communications systems, which propagate through the Earth's crust to insure survivability against bomb damage, was detailed at the Nov. 4-6 Northeast Electronics Research and Engineering (NEREM) meeting here.

Scientists from the Air Force, Radio Corp. of America and Raytheon Co. disclosed work on three different approaches. The one thing common to all approaches is that only very low data rates can be achieved. But scientists report that because of the extreme invulnerability of these systems, the high security aspects, and generally low ambient noise conditions, the costs of such systems may be justified for possible use as emergency communications modes between hardened military installations.

The Air Force study program in electronic propagation dates back to about 1958, and is still being pursued by the Air Force Cambridge Research Laboratories. Observers close to the project say that some of the initial work was aimed at disproving the concept's applicability to long-range communications, which it apparently has done. But in the course of these studies, it was shown that short-range communications were feasible and do look promising. No program is believed to be under way that is aimed at associating these techniques with existing installations.

● **Air Force effort**—The Air Force technique, not dissimilar from that used by geophysicists for various Earth measurements, involves injection of large currents at ultra-low-frequencies (on the order of 1cps) into the Earth through electrodes. By the use of wide spacing between electrodes and sophisticated detection equipment, scientists say that contact between terminals can be effected to distances in excess of hundreds of miles.

Communications at fractional bit rates, however, will be limited to ranges of about 20 miles for usable communications. The scientists stress that because of major variations in the Earth's resistivity at various places, each proposed location must be viewed as an individual problem.

Choice of the 1 cps frequency is generally dictated by a reduction, at that frequency region, of the effect on the signal of background noise originating in the atmosphere as well as variations in the Earth's electric field, both of which induce distorting voltages on receiver electrodes.

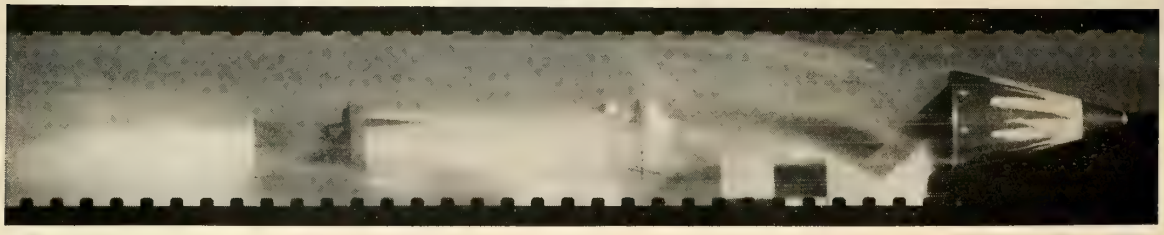
An RCA scientist, discussing the use of seismic communications over ranges up to 5,000 km, said that although the cost of such a system would be high, and the data rate low, it too may bear justification because of its relative invulnerability.

● **RCA reports**—RCA's K. H. Powers pointed out that evidence collected thus far by seismologists, and measurements taken during underground nuclear test explosions, indicates the existence of a sound channel (somewhat similar to that which occurs during the use of sonar at significant depths) at a depth of about 80 km under the Earth's crust.

As a seismic ray hits this so-called "low velocity" or negative-gradient layer with near-grazing incidence, the wave tends to be bent downward until a positive gradient at greater depth reverses the direction of the ray. This creates a waveguide-type mode of propagation through which seismic waves can be trapped and allowed to travel great distances with relatively low attenuation.

Since most of the high-attenuation and multipath phenomenon characteristics of seismic propagation usually take place in the 30-km-deep crystal layers of the continents, Powers says it would be advantageous to locate both transmitter and receiver as deeply as possible in the ground.

This would allow a more direct cou-



Re-Entry Vehicle Hurtles Through Simulated Rain

METAL AND PLASTIC nose cone fastened to monorail rocket sled is shown in one of several tests run to determine effects of rain erosion on missile nose cones during re-entry. A total of 16 tests has been run at speeds ranging from 1,400 mph to 1,900 mph on the high-speed test track at Holloman Air Force Base, N.M. The "rain" is a 6,000-ft. area of precisely controlled spray shooting at the nose cone through a double row of nozzles bordering the 35,000-ft.-long track. Nozzles can emit up to 5,000 gpm. The program yielded accelerations as high as 47 g's to meet exacting test conditions. Tests were conducted by the Track Test Directorate for the Harry Diamond Laboratories, Washington, D.C. A 35-mm image motion compensation camera with continuously moving film shot this unframed pictorial record of one of the rocket sled runs.

pling to the Earth's mantle, reducing the generation of surface waves and also cutting the microseism noise at the receiver site. Powers says that under these conditions, a means of communication between deeply buried sites on the East and West coasts of the United States may be possible at data rates of about one bit per sec.

The Raytheon efforts, also pursued under an Air Force contract, focused primarily on radio propagation modes directly through rock strata between pairs of antennas.

● **R&D spending trend**—In other NEREM activity, a discussion among top scientists and business leaders reached a consensus that spending for defense R&D was not likely to experience any drastic reductions from the 1964-1965 levels in the next few years, and could even exhibit another period of upswing in the not-too-distant future. The nation's space budget was seen as also holding to current levels, with possibly a slight increase in the future.

Participating in the session were Dr. Jerome B. Wiesner, former science advisor to President Kennedy and now dean of the Massachusetts Institute of Technology School of Science; John H. Rubel, former Department of Defense Research and Engineering deputy now a vice president of Litton Industries, Inc.; C. Lester Hogan, vice president of Motorola Semiconductor Products Div.; and Leonard S. Sheingold, vice president of Sylvania Electronic Systems.

Sheingold hit at the use of the word "conversion," which is commonly applied to current defense industry problems. He said what is needed is a program of "diversification" not conversion, for additional stability. He proposed that firms do less talking and more looking at some of the possibilities in the non-defense sector.

He said there are many non-defense industries and companies that could benefit from the technological capabilities of defense firms. The combination of defense technical personnel and non-defense sales prsonnel could be rewarding, he suggested.

Sheingold said there were many non-defense companies in the U.S. that could be revitalized, and that defense firms ought first to look over their capabilities and then, after careful study, approach commercial firms with perhaps initial explorations into new business ventures. Tax reductions making more risk capital available will be helpful.

At the same time, Sheingold warned that the government may be asking too much of defense firms, wanting them to use their excess capacity properly, yet still demanding a fast reaction time.

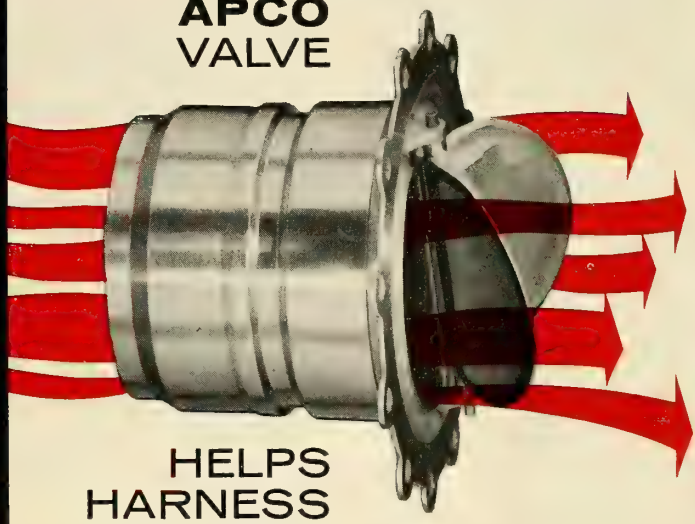
● **Electronics future promising**—Dr. Hogan, focusing on the electronics industry, was generally bullish, predicting that despite reduced government spending in the next few years, the trend for the industry over the next 10 years would be upward.

He said that because of continuing innovation, speculators can be far off in even trying to predict short-range prospects for the industry. He said the industry generally had a tendency to underestimate its technical progress, which he feels is the easiest part of the problem to see. Next year, he said, the industry will sell the same dollar volume of integrated circuits as it did transistors in the big transistor year of 1957.

This year's total $18-billion price tag for government and industry R&D will grow to about $38 billion by 1975, according to a Stanford Research Institute report. Expenditures throughout the world could probably push this figure to $55 billion, Hogan asserts.

He said the trend to microminiaturization would continue, with increased complexity per functional block, and reduced cost per function. Integrated circuits representing complete circuit functions will eventually cost less than a transistor now costs, and electronics applications that are not now economically feasible will become so. ■

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General Dynamics Proposes Up-Rated Atlas as Titan III-X Competitor

Performance boost of 30% promised without Floxing; reliability record cited; opposition to cryogenics seen as major hurdle

GENERAL DYNAMICS/ASTRONAUTICS, seeking to extend the life of *Atlas,* has come up with proposals to make its *SLV-3* vehicle competitive with *Titan III-X,* which in recent weeks has moved up for top-level development decision in the Department of Defense.

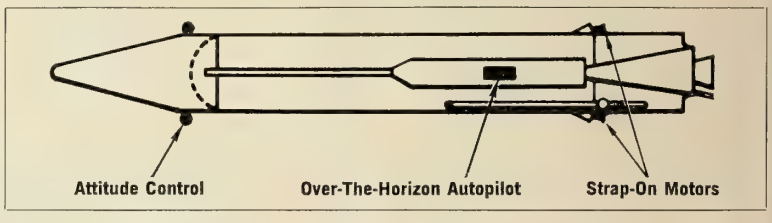
In presentations to the Air Force and NASA, the company has proposed upgrading *SLV-3* performance by 30% across the board, with modifications that include engine changes, miscellaneous weight reductions, decreased propellant pads, tank geometry changes and associated ground equipment modifications.

This could be done without degrading reliability, according to GD/A, which recently has proposed a fixed-price contract to the Air Force for follow-on *Atlas* procurement in 1966. Current *Atlas* business will carry through 1965.

● **Souping it up**—A 30% performance improvement still would leave *SLV-3* capability below that of *Titan III-X/Agena D,* but *GD/A* believes it would be competitive with the proposed new launch vehicle. Further, if an *Atlas* Flox program were to be added to these improvements later, the result reportedly would be a vehicle with a payload capability nearly 1,500 lbs. greater than that of *Titan III-X.*

According to GD/A, both the improvement and Flox programs would cost less than developing the new launcher.

The *Titan III-X/Agena,* recommended by the Air Force Space Systems Division as an economical vehicle to replace the *Atlas-Agena D* for unmanned payloads in the latter part of this decade, would orbit payloads in the 3,000-to-6,000-lb. category. A Floxed *SLV-3* alone, without the proposed 30% improvement through modifications, would fall about 200 lbs. short of this, according to GD/A.



SLV-3 configuration proposed for circular orbit missions.

The company also has considered several new *SLV-3* configurations to increase cost effectiveness, including an apogee kick version and one that would use a solid second-stage vehicle.

● **Anti-cryogenic school**—Biggest hurdle faced by GD/A's proposals, according to some Air Force sources, is the desire to get away from cryogenics for military launch systems regardless of the reliability record they have established or what could be done to upgrade *Atlas.*

"From the standpoint of advanced planners, the days of the cryogenically fueled boosters for military programs are numbered," an Air Force spokesman told MISSILES AND ROCKETS. "They feel that eventually there is only one way to go and that is with storables or solids or a combination of both.

"*Titan III-X* would extend to the *Agena* the versatility, flexibility, cost savings and the instantaneous reaction time that are inherent in a storable-propellant vehicle. Why continue to operate with all the constraints and problems associated with cryogenics when with the *Titan III* program we've got two-thirds of the $800 million development cost already spent?"

The spokesman added that many arguments against *Titan III-X* could be expected, not only the technical arguments of technical people who point to the reliability of cryogenics, but political arguments against killing off a program in an area of the country where this business is an important part of the economy.

Titan III-X essentially is a *Titan III-A* without the transtage propulsion system since *Agena* has its own, and with the transtage guidance and control system put into the adapter section that would mate *Agena* to the second stage. It would have provision for solid strap-ons.

● **Opposition to storables**—Proponents of keeping *Atlas* in the launch vehicle stable question whether the Air Force really needs a storable-propellant vehicle for space reaserch launch purposes and whether a storable system would be cheaper in the long run.

"If you're using cryogenics for individual space launches and not from silos, they are cheaper due to the higher cost of storable propellants," an industry source said. "*Atlas* launch costs are substantially less than *Titan* launch costs because of this, and the vehicle itself also is cheaper.

"As far as quick reaction to meet launch windows is concerned, the probability is quite high with cryogenics. You start your countdown earlier, but this doesn't appear to be adverse for space launches. So why throw away the reliable cryogenic system we have paid for just because it's cryogenic?"

The spokesman added there had been "a certain amount of resistance to Flox because people don't understand the nature of it. The degree of toxicity is no more than in existing storables,

and a system containing 30% Flox (studied for *Atlas*) has less toxicity than a comparable storable-propellant system."

GD/A, working with Rocketdyne division of North American Aviation on proposed engine changes, has told the Air Force that modifications for the 30% performance increase could be accomplished in 18 months.

Current *SLV-3* performance capabilities, with launch from the Eastern Test Range, include: *SLV-3* alone to 100 n. mi. orbit, 4,100 lbs.; *SLV-3/Agena D* to 100 n. mi. orbit, 6,900 lbs.; *SLV-3/Agena D* to escape, 1,200 lbs. under ideal conditions.

● **Modifications detailed**—The firm's recent Air Force briefings project an across the board increase of 30% if all of the proposed modifications are made.

Three booster engine thrust values were considered in studies, including the present 165,000-lb.-thrust MA-5 booster engine, the yet-to-be developed 175,000-lb. unrated MA-5, and the existing H-1 engine if uprated from 188,000 lbs. thrust to 200,000 lbs.

A change in tank geometry to a constant 10-ft.-dia. configuration to gain additional propellant would be necessary to make uprated engines pay off and would mean a significant payload increase with the present engine.

When the original *SLV-3* criteria were compiled, the *Orbiting Astronomical Observatory (OAO)* and *Satellite Inspectors (SAINT)* configurations dictated the magnitude of the launch vehicle bending during flight. The *OAO* program now has its own tank configuration and *Satellite Inspector* has been cancelled, allowing reduction of structural criteria for a constant 10-ft.-dia. tank.

This reduction permits sizeable reduction in LOX tank skin gages. It also makes the constant 10-ft.-dia. tank, which permits a propellant gain of about 19,000 lbs., desirable for all existing *SLV-3* programs.

Engine change proposals include new booster engine injectors, which could be taken from the existing H-1 engines and modified slightly to the MA-5 propulsion system. The sustainer engine would be uprated from 57,000 lbs. to 65,000 lbs. thrust by increasing turbo-pump speed and propellant flow rate, which would not involve a major hardware change. The sustainer also would receive a new turbine.

● **Trimming the weight**—Weight-saving modifications would include reduction of the thrust build-up acceleration factors by as much as 10-15%. Fuel tank pressure could then be lowered and skin thickness reduced accordingly to save 100 lbs.

GD/A tests show that about 80% of the steel purchased for tank skins has a tensile strength of 220,000 psi or better. If the procurement specification were changed or if only the higher strength material were selected from present deliveries, the higher strength could be guaranteed and skin gages decreased for additional weight saving of 140 lbs.

Further weight reductions would be made by shortening the B-2 pod to cut 60 lbs., reducing the number of hydraulic accumulators for a 50-lb. cut, reducing width of skin splice overlap, re-routing hydraulic and pneumatic tubing and eliminating about 20 lbs. of paint on maintenance walkways.

It also may be possible to remove 80 lbs. of baffles used in the LOX tank to prevent sloshing, since preliminary analysis shows this is not a critical condition.

● **Propellant pad changes**—The propellant pad also would be reduced. The pad now is necessary to compensate for dispersions of engine, propellant utilization system and autopilot performance. Two items contributing to dispersions are gyro drift and ac voltage and frequency control. The pad could be reduced by using low-drift gyros and changing from a rotary inverter to the static inverter developed for the *Centaur* program.

The *SLV-3* autopilot is constructed to accept steering commands from the guidance system during the booster phase of flight. In programs not using this capability, performance would be increased by reducing the propellant pad through incorporation of this capability into the guidance equations.

"Soft" shutdown of the launch vehicle (burning to LOX depletion) on *Agena* missions would reduce propellant pad by 130 lbs. Computation of required propellant pad would be based on the probability of a low-performance *SLV-3* combining with a low-performance *Agena*.

The propellant pad could be further decreased by optimizing the pitch program for each specific mission, increasing payload on programs not near their optimum condition. A standard pitch program now is used for all *SLV-3* missions.

Ground Support Equipment modifications to improve flight performance would include pressurization of the LOX loading system with helium instead of nitrogen. The inert nitrogen is soluable in LOX, while helium is insoluable.

A second GSE modification would replace the Barksdale pneumatically activated valves in the launch-release mechanism with pyrotechnic valves. This change would result in release of the launch vehicle 0.36 sec. earlier after ignition, permitting more propellants to be used for mission accomplishment.

● **New shapes studied**—Still in the study stage are three new configurations for *SLV-3*. One proposal is for a light-weight *OAO*-type of booster for missions not requiring a relatively high-performance second-stage such as *Agena* or *Centaur*. Tank skins would be light with the tank pressures reduced, and the vehicle could accommodate a solid second stage.

A series of adapters would be supplied to accommodate spacecraft needs for 5-ft., 8-ft., or 10-ft. shrouds. This volume would allow large, low-density payloads and permit spacecraft simplification by such means as eliminating the necessity of hinging. The large volume would shroud winged vehicles as well as more conventional payloads.

GD/A has been studying a family or solid second-stage vehicles for such programs as *Advanced OSO, Nimbus, Advanced BIOS,* and the Comsat Corp. satellite used with *SLV-3*. These include the Project Fire velocity package, Burner II, and the Weight Lifter.

The Weight Lifter program is one of a GD/A family of proposed solid second stage vehicles. The company would buy an off-the-shelf solid rocket and build components around it. It would be the same size as the Fire program velocity package, an X-259 with 24,000 lbs. thrust.

● **Broadening mission scope**—An apogee kick configuration for *SLV-3* is being considered to expand versatility and its application to programs not requiring a second-stage vehicle. The circular orbit capability of the *SLV-3* alone is presently limited by the relatively short burn time.

In the apogee kick configuration, the launcher's velocity, attitude and direction at sustainer shutdown would be controlled so that the vehicle would coast on a Hohmann transfer ellipse to the desired apogee. A velocity change then would circularize the orbit through use of small solid motors mounted on the *SLV-3*.

In its Flox studies under contract with NASA's Lewis Research Center, GD/A reports component testing with Flox "confirm that no extensive modifications would be necessary to existing *Atlas* systems."

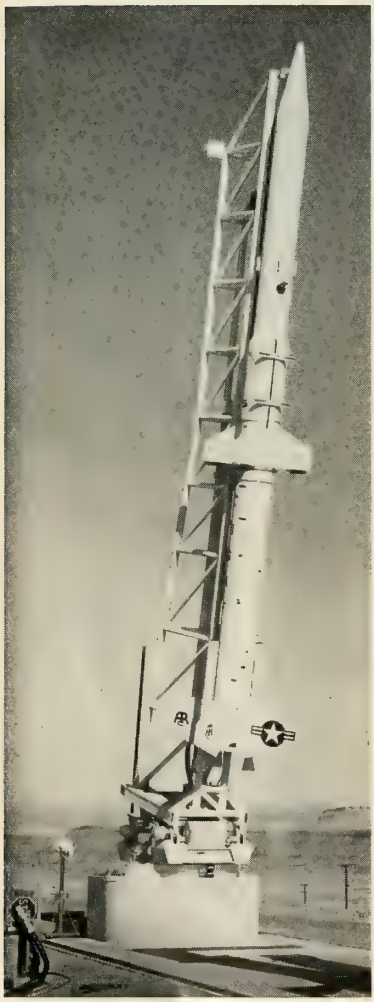
Studies indicate that an *Atlas* using a 30% Flox mixture could achieve an 88% increase in payload for 100-n. mi. orbits; for *Atlas-Agena* combinations a 65% increase in payload can be achieved for Earth-escape orbits, and for *Atlas-Centaur* a 35% payload increase can be achieved for the *Surveyor* spacecraft designed to impact on the Moon.

Rocketdyne was recently awarded a contract for performance tests of the *Atlas* sustainer engine using a 30% Flox mixture. Sustainer engine firings will be conducted in that test program, scheduled to begin after the first of the year. ■

Athena Scores First Success

Fourth launch of four-stage rocket propels sub-scale ICBM re-entry body to White Sands target at 22,000 fps; called unqualified success

by Charles D. LaFond

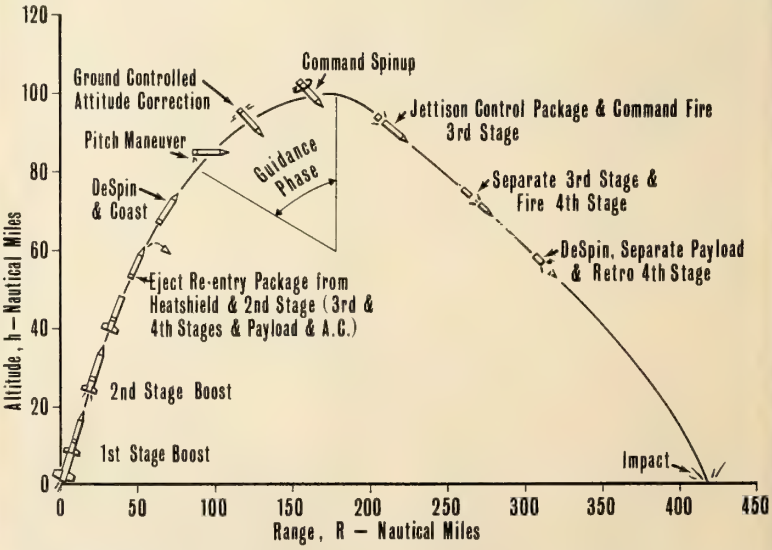


THE FIRST successful flight of a fully instrumented, four-stage *Athena* re-entry research vehicle was achieved on Nov. 6.

Termed an "unqualified success" by range observers, the mission was the first in which the *Athena's* velocity package was employed to drive a sub-scale ICBM re-entry body back into the atmosphere at 22,000 fps. Launched from Green River, Utah, the payload covered approximately 417 miles and impacted nearly on target within the White Sands Missile Range, N.M.

Under development for the Air Force Ballistic Systems Div. by Atlantic Research Corp., prime contractor for vehicle integration, the *Athena* is intended to significantly lower research costs in the future study of offensive ballistic-missile penetration techniques. A part of the *Advanced Ballistic Re-entry System (ABRES)* program, the vehicle is being developed under a 3½-year, $48-million contract awarded to Atlantic Research Corp. May 1, 1962.

Following two aborted test flights on Feb. 11 and May 28, the first successful flight of an *Athena* was accomplished on July 8. Carrying dummy third and fourth stages, the third test vehicle, also launched from Green River, impacted some 470 miles down-range at WSMR. The most recent firing was fourth in the series of test flights and was designed not only to test the research vehicle but



LEFT: The Athena under development by Atlantic Research Corp. for the Air Force Ballistic Systems Div. shown ready to fire from 30-ft.-long rail launcher. Rocket measures 50 ft. in length, weighs more than 16,000 lbs. at launch. RIGHT: Typical flight profile for Athena from Green River, Utah, to White Sands Missile Range.

to obtain re-entry data on a subscale Mark VI nose cone for comparison with data obtained from previous *Atlas-E* flights from the Eastern and Western Test Ranges.

● **ABRES program**—*Athena* at one time was the code designation for the *ABRES* program and has since been given to the research vehicle to be employed in the program. The whole effort is under the direction of the Air Force Ballistic Systems Div., Air Force Systems Command.

Total *ABRES* funding in Fiscal 1964 was $218.6 million with $40 million budgeted for the *Athena* two-year development. The latter has been extended both in time and funding.

First flights in the *ABRES* program began in 1963 using existing ICBM's. The goal then was to determine the scaling factors necessary to permit meaningful use of smaller experimental payloads on *Athena* research flights. An underlying goal in *ABRES* is to greatly reduce re-entry research costs by finding a way to conduct such studies with subscale models.

Final determination of scaling laws must await successful completion of flights carrying identical payloads for comparison aboard *Atlas* missiles and *Athena* vehicles (with scaled payloads).

To support the studies, advanced radars will be employed to obtain signature data for use in determining warhead identifying characteristics (wakes, shapes, sizes and weights). Also, a variety of re-entry body shapes, decoys and electronic countermeasure systems will be employed to study methods for confusing or deceiving defensive systems.

During the program, the Navy's Special Projects Office and the Army will take part in some tests.

● **Athena project profile**—The *Athena* research vehicle is designed to use four stages—two up and two down—sequentially fired. It employs an inertial reference and radio-command control to permit attitude correction of the velocity package just prior to third-stage firing. Programmed re-entry angles of from 18 to 46 degrees will be obtainable.

Atlantic Research is prime vehicle integrator; Honeywell, ARC's principal subcontractor, is guidance system developer.

Continental Electronics is prime contractor to Rome Air Development Center for the two new L-band/Ultra High Frequency Pencil Beam Radars used to obtain re-entry tracking data from the WSMR impact area.

As presently conceived, the *Athena* is final-assembled and launched from a complex built for the *ABRES* program at Hanksville-Green River, Utah. The vehicle is rail-launched, but during the first and second-stage boost, it is unguided. Thus, to assure attaining the desired course and spatial location near apogee, meteorological rockets are fired from Green River just prior to the *Athena* launch to attain azimuth and elevation corrections.

AN/FPS-16 radars are used at the Green River launch area for tracking inputs to Range Safety.

Following second-stage separation and heat-shield ejection during the upward coast phase, a pitch maneuver is performed and, via ground radio control, the planned vehicle-attitude correction for re-entry is made. The control package is then ejected, the third stage ignited and the velocity package starts its acceleration downward. After the fourth stage is fired and separated, the re-entry body continues a ballistic course to impact on the WSMR.

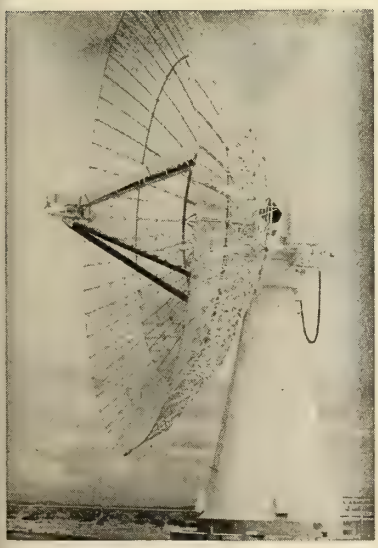
The flight covers some 417 miles, permits a payload test altitude of roughly 250,000 feet and achieves a re-entry velocity of about 22,000 fps. with nominal payload of 50 lbs.

Two L/UHF radar tracking sites are employed at WSMR. The *Athena* flight plan must be such that the payload arrives on a course no closer than 20 miles to one, named Stallion Site, and will impact at least 20 miles ahead of the other, called Ram Site.

Stallion Site, employing a Continental 30-ft.-dish L/UHF radar and a Marchetti radar, tracks from a side aspect. Ram Site, using a second L/UHF radar with an 84-ft. dish plus a Raytheon Rampart radar and an AMRAD radar, looks at the payload from a head-on aspect.

● **Vehicle design**—Functionally, *Athena* consists of two major sections: the booster and the velocity package.

The booster airframe is fin-stabilized and consists of a Thiokol XM-33-E8 Castor motor with two Thiokol XM-19-E1 Recruit motors in the first stage and either a Thiokol TX-261-2 motor (for *Athena* Mod. I) or a Hercules X259A2 Antares-II motor (for *Athena* Mod. II). The second stage motors are made interchangeable through the use of different adapter ring assemblies. The *Athena* Mod. I version will be used for missions requiring re-entry angles from 18 to 30





L/UHF PENCIL Beam Radars, developed by Continental Electronics, are key tracking instruments supporting Athena re-entry studies. Sites, located at White Sands Missile Range, N.M. use an 84-ft. dish (left) and a 30-ft. reflector (right) to transmit and receive L-band and UHF signals simultaneously. Athena launches take place from Green River, Utah.

degrees; the Mod. II version will permit re-entries in the 40- to 46-degree range.

Both stages are provided with four canted aerodynamic fins. Four spin rockets in the trailing edges of the second-stage fins produce up to a three rps spin rate just after launch. The forward motor sections in each stage are provided with a command-destruct component.

The velocity package includes the third and fourth stage motors, the guidance and control subsystems, electronic subsystems and power supply, a retro motor and a heat shield.

Third stage of the system employs an Aerojet-General 30KS8000 motor and contains the guidance and control assembly plus yo-yo de-spin and spin-up motor systems. The G&C assembly includes a PAM/FM/FM telemetry subsystem providing 17 continuous and one commutated IRIG standard subcarriers at 245.3 mc. Also, it includes a command receiver and the attitude control system.

The attitude reference system uses two 2-degree-of-freedom gyros for three-axis displacement sensing. Attitude corrections derived from gyro errors through the control system are applied through actuation of six cold N_2 gas reaction jets.

Fourth stage of *Athena* consists of a Hercules BE-3-4A motor, a chemical de-spin/re-spin system, retro-rockets and an instrumentation section. The latter includes a C-band radar beacon for range safety and tracking requirements, timers, a telemetry system similar to that in the third stage, but operating at 259.7 mc. and a battery pack for electrical power. In addition ,the last stage includes the payload support structure.

● **Flight sequence**—*Athena* is launched from a 30-ft. rail at nominal angles of 156°AZ/75°EL for Mod. I and 151°AZ/76°EL for Mod. II.

When clear of the launcher, the spin motors are ignited to assist flight stability and to average out thrust misalignments. The first stage motor provides a total thrust of 122,000 lbs., over a 40-second burning period.

Second stage motor operation varies considerably between the two versions: Mod. I (using a TX-261) achieves 57,000 lbs. thrust over 13 seconds; Mod. II (using an X259) achieves 19,000 lbs. thrust during a 34-second burning time.

The nose cone heat shield is ejected from the vehicle at about 300,000 ft. altitude and the velocity package is ejected out of the front of the remaining cylindrical heat shield. The velocity package is ejected with a spin rate of three rps.

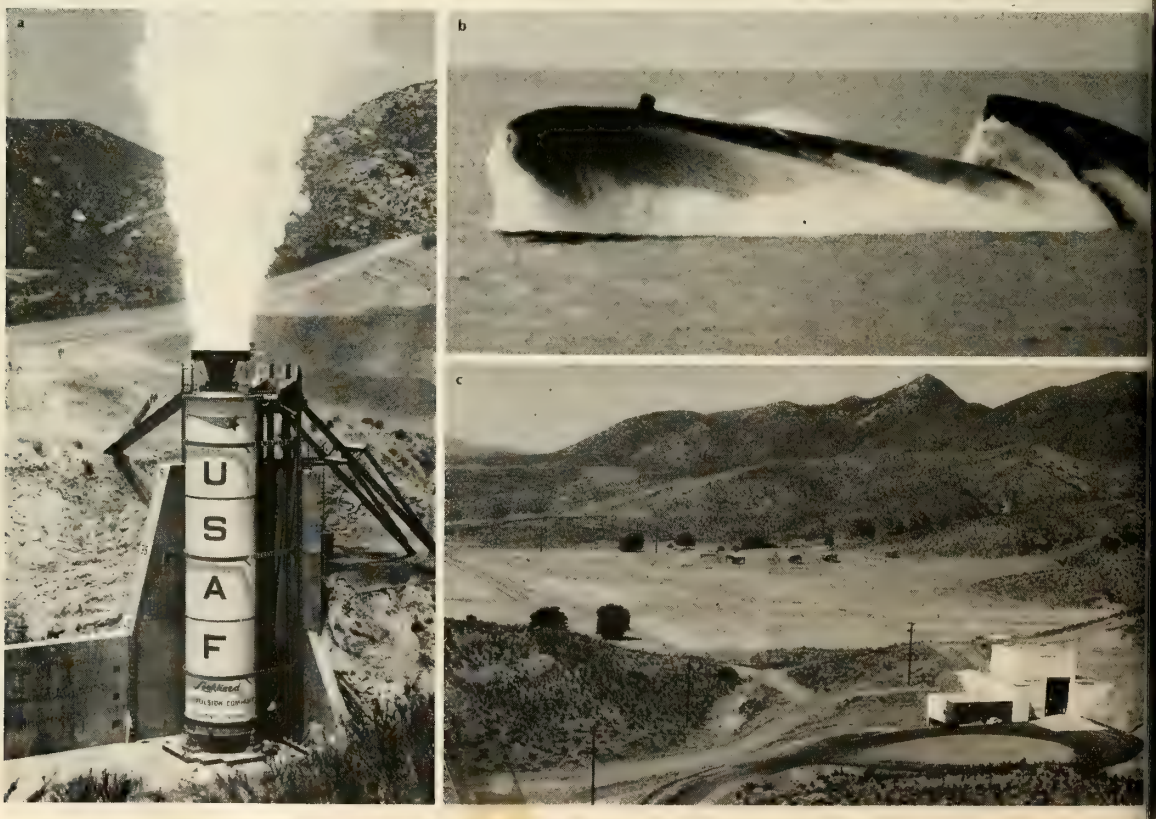
Before actuation of the attitude control system, the test vehicle is de-spun. All remaining motion in each axis is stopped by the attitude controller and the planned orientation for re-entry is made.

When all attitude corrections have been made and verified by ground control, the vehicle is re-spun to 5 rps. Then in sequence—as directed by a mechanical timer—the guidance system is jettisoned, third stage fired and later separated, fourth stage fired and later separated and slowed by retro-rockets. The payload continues on to impact.

● **Key tracking radars**—The L/UHF radars developed by Continental to support the *ABRES* program were developed under a $5.5-million contract awarded in June, 1962, and completed by June, 1964.

First full operation of the two stations was achieved by Oct. 1, 1963. Under a separate contract with the Air Force Missile Development Center, Holloman AFB, Continental provides operation and maintenance services for L/UHF sites. Between 40 and 45 flight missions have been tracked to date by the radars.

The two systems developed by Continental are essentially the same, differing primarily in the size of antennas used. The AN/FPA-22 uses an 84-ft.-



dia. paraboloidal reflector; the FPA-23 employs a 30-ft. dish.

Each station is provided with two transmitters and four receivers. Both antennas produce 30-Mw peak power output at each frequency with a 100-pps repetition rate. They are limited to ±110-degree rotation in azimuth and cover the range from 0 to 90 degrees in elevation.

The two antennas are directed on target by an IBM-7094 computer facility using data obtained from six range trackers. Accuracy of both new systems, reportedly, is to within ±0.01 degree.

Considerable effort has gone into the design of both the Ram and Stallion Sites to protect personnel from sidelobe and backlobe radiation and to shield the receiving equipment. As one Continental official put it, "These radars radiate more energy by accident than most others do on purpose."

● **Unique antenna feeds**—Both dishes and their supporting drive mechanisms and pedestals were developed for Continental by Kennedy Antenna Div. of Electronics Specialty Co.

A unique feed-horn assembly, developed by Continental with LTV Electronics, is used with both antennas. The feed permits simultaneous transmission and reception at L-band and UHF. Both transmitted signals are vertically polarized. Received signals at L-band and UHF are vertically and horizontally polarized.

Antenna gain with the 84-ft. dish at L-band is 48 db and at UHF, 38 db. For the smaller dish, the gains respectively are 39 and 29 db. Beamwidths at L-band and UHF for the 84-ft. dish are 0.65 degree and 2 degrees; for the smaller antenna, 1.8 and 5 degrees.

Average transmitted power at both frequencies is 60 kw total.

Sidelobe radiation at the Stallion Site has been measured at about 300 kw and for the Ram Site about 150 kw.

● **Equipment shelters**—The L/UHF stations are fenced and access is by safety tunnels. Transmitting structures are 22 ft. high to permit crane removal and installation of the 12-ft.-high, 1,200-lb., power-amplifier tubes. Shelters were built for Continental by Building Mart of El Paso, Texas.

Shelters are steel walled with the sheathing taped together at the joints, primarily for radiation protection for personnel within the building. Receiver rooms are double shielded.

Ninety-four tons of air-conditioning equipment is required at each site to cool the power-amplifier systems and maintain a habitable ambient temperature for personnel.

The large power-amplifier tubes (encased in 2-in.-thick lead containers for X-ray protection) were developed for the systems by Litton Industries: an L-3775 UHF tube is a four-cavity klystron tunable across the frequency band of 425 mc ± 5%; and an L-3823 for L-band is a broadband klystron. Other transmitter equipment includes ignitron modulators (developed by Ling Electronics), travelling-wave-tube drivers, and crystal controlled exciters.

The receiving system, developed by Temco Aerosystems, employs four receivers per site to measure both frequencies and both polarizations.

● **Antenna control**—Because of the very narrow beamwidths produced by each antenna, steering inputs must be extremely precise. The Ram antenna, for example, must be aimed within ± 0.18 degree of the target to illuminate it.

Several modes of control are available for the two antennas. An antenna control console at each station permits manual synchro steering and the same capability is provided at the site manager's console.

Land lines from adjacent range radars provide inputs for automatic synchro steering. In addition, signals via a Kineplex link from the WSMR computer complex are provided for digital steering of the antennas. ■



a *The world's largest solid rocket motor develops over 1,000,000 pounds thrust. Two successful test firings of the 156-inch giant have demonstrated several new advances in solid propellant and rocket technology.*

b *Nuclear submarine and crew safety will be improved by an emergency ballast expulsion system now under development at Lockheed Propulsion Co. Solid propellant gas generators will expel tons of sea water at least ten times faster than present methods.*

c *Additional production facilities installed on Lockheed's 9,100 acre production and motor test site at Potrero, California, now double the capability for large solid motor production from two plants.*

d *New 300-gallon propellant mix station has been installed at the Potrero facility. It produces 60,000 pounds each 24 hours.*

e *Full scale test of jet tab system adds further breadth to Lockheed Propulsion's unique experience in several large motor thrust vector control systems.*

A candid look at Lockheed Propulsion Company

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LOCKHEED PROPULSION COMPANY

A DIVISION OF LOCKHEED AIRCRAFT CORPORATION

'Observatory' Aircraft Proposed For Better Satellite Inspection

Perkin-Elmer study indicates mobility, lack of atmospheric limitations would give better resolution than ground telescopes

by Rex Pay

SAN DIEGO, CALIF.—Satellite inspection through telescopes mounted in aircraft would give a gain in resolution of two to three times, according to a study made by Perkin-Elmer Corp.

Aim of the study was to find out how much detail on foreign satellites can be seen through telescopes—on the ground or in aircraft.

Use of aircraft increases the probability of being able to observe a satellite.

Atmospheric conditions limit the location of ground observatories for satellite inspection to the southwestern United States and Hawaii. The geometric probability that one of these sites will be within a 400-mi. ground track of an orbit of arbitrary longitude is only between 2% and 4% if orbit inclination is significantly greater than site latitude—as it is for Soviet satellites.

But a fast aircraft, given the approximate ground track of the next pass of a satellite in a spherical orbit, might be expected to intercept the satellite over a 1,600- to 2,000-mi.-wide band of the surface traced out by the satellite.

The aircraft's mobility would give an even greater advantage for elliptical satellite orbits.

If the aircraft flew at 40,000 ft. altitude, the daytime sky brightness would be about one fourth the brightness at 5,000 ft., making the satellite easier to observe, and cloud cover would be much less of a problem.

● **Resolution considerations**—Intelligence on the foreign satellite's purpose is expected to come from an ability to distinguish openings or windows, antennas, rocket engines, and markings —all of which call for a system resolution of about one foot.

Atmospheric conditions limit ground telescope resolution to about one arc second. This means that details of 3 ft. will be resolvable on a satellite 100 mi. overhead. But looking at the same satellite at an elevation angle of 30°, the system would only resolve details of six feet. For a satellite in a 200-mi. orbit, at the same elevation, details resolvable would measure about 12 ft.

Better resolution can only be gained by going above the atmosphere. An airborne system flying above 30,000 ft. could expect an average image blur due to atmospheric effects of 0.3 to 0.8 arc seconds by night, and 0.4 to 1.0 arc seconds by day. The corresponding figures at a high-altitude ground site are 1.0 to 3.0 arc seconds and 0.75 to 2.0 arc seconds.

The Perkin-Elmer study showed that foreign satellites can be inspected by day, as well as during dusk and twilight.

Results of the study were reported by C. S. Lapinski, M. F. Maguire, and F. S. Repogle to the recent Ninth Symposium on Ballistic Missile and Space Technology here.

● **Disadvantages**—Chief disadvantage of aircraft observation, reported the group, is that readiness and reliability of one complete airborne system will probably be significantly lower than that of a single ground station. Other disadvantages for the airborne system are greater difficulty in acquisition and tracking, and need for a larger operating crew.

The Air Force has not announced any program for the airborne inspection of satellites, but is installing a ground satellite inspection site at Cloudcroft, N.M., as an R&D system to evaluate the potentialities of electro-optical systems for satellite inspection.

If results of the Cloudcroft experiments, due to start this year, are good, an airborne system would presumably receive consideration.

The airborne tracking of satellites is receiving its first publicized funding with the conversion of twelve C-135 jets to function as command and telemetry stations for NASA during the injection phase of *Apollo* lunar flights. In this aircraft, however, the tracking is carried out by a steerable S-band antenna in a nose radome.

Demonstration of the suitability of a jet transport as an optical observation platform was given during the July 20, 1963, eclipse of the Sun. Then a Douglas DC-8 flying at 525 mph carried a spectrograph, infrared equipment, image converters, motion- and still-picture cameras, and other equipment at an altitude of 40,000 ft. for eclipse recording over a period of 142 seconds.

During this time, the autopilot, specially adjusted by Sperry-Phoenix Corp. for this flight, kept DC-8 roll movements below 0.25°, and pitch movements even lower. Within the aircraft, a six-inch reflector telescope coupled to the spectrograph was illuminated by a heliostat tracking mirror, which, with the aid of a gyro-stabilized platform, enabled the Sun's image to be tracked with an accuracy of one minute of arc.

A somewhat better tracking accuracy would be needed for the airborne satellite inspector system, which would probably have a field of view of about two minutes of arc. Also, the satellite would appear to move considerably faster than the Sun.

● **Present system details**—The present ground station for inspecting satellites, using the 48-in.-aperture telescope at the USAF Electro-Optical Observatory, Cloudcroft, has a 312-in. focal length primary system that can be expanded in steps to 3,000-in. focal length. In comparison, 200-mi.-range photo-

graphs of *Sputnik II*, which showed its length to be 79 ft. (with 5 ft. uncertainty), were taken with a 24-in. aperture telescope operating at 500-in. focal length. Specular reflection obscured all detail on the satellite.

The new Air Force telescope is mounted on a large prcision three-axis mount with setting, track, and cross-track axes.

Primary means of acquisition is by two five-inch aperture manual telescopes mounted north and south of the main observatory. Backup acquisition is obtained by pre-programming the large telescope to look angles predicted from the radar tracking net.

Tracking is carried out by a 15-in.-aperture telescope, mounted alongside the 48-in. telescope, equipped with an image orthicon detector with angle gates.

Main detectors for the telescope are also image orthicons, with both video recording and monitor photography being used.

● **Airborne system requirements**—For a detector element in an airborne electro-optical system, the Perkin-Elmer group recommends a two-stage image converter, such as the RCA C70012. This is said to be capable of a total resolution over a 3.5-in.-dia. photocathode of 3,500 line pairs. It has a maximum input-to-output light flux gain of 1,500 times. Assuming the light at the output phosphor can be collected and imaged on recording film at 5% efficiency, exposures on the order of milliseconds are feasible.

If the aircraft is flying at about 600 mph, the exposure time needed to eliminate image blur must be 0.5 millisecond.

At altitudes above 30,000 ft., the aircraft boundary layer turbulence will scatter only a few percent of the illumination transmitted through it. This does not significantly limit system resolution.

If the "seeing" limitation from the aircraft is 0.25 arc-second, a field of view of three milliradians could be used, provided the resolution capability and short exposure time of the image converter are available. Minimum aperture of the main telescope would be about 24 in. and its focal length would be about 1,600 in.

Compactness is a prime consideration in airborne systems, and the basic Flüge form of telescope would probably be used. This has two principal elements, the front corrector with the secondary mirror on the back surface and the main mirror. A transfer lens system provides the necessary power change.

Both optical and radar acquisition aids would probably be needed in the aircraft. ■

Sandia Tests Revamping Data About Radiation Damage to Transistors

SEATTLE—Radiation damage to silicon transistors can be much worse than measurements made several hours after exposure indicate.

Previously, the assumption has been made that transistor gain at any time after irradiation is constant. But measurements at Sandia during exposure of transistors to 10^{13} nvt showed that transistor current gain typically falls to a minimum value near the end of the radiation pulse and then begins to recover, reaching a constant value.

This finding is particularly significant for circuits that have to function correctly within a fraction of a second of a radiation blast. In extreme cases, the Sandia tests showed that the gain one millisecond after a neutron burst may be equivalent to the constant-value gain predicted for double the neutron exposure.

Results of the Sandia tests were given by H. H. Sander at the recent Nuclear Radiation Effects Conference here, which is jointly sponsored by the IEEE Professional and Technical Group on Nuclear Science and by the University of Washington.

● **Gain change traced**—Sanders said that the shape of the gain-recovery curve was similar for all silicon transistors tested, but the amount of recovery varied with the type of transistor and the time-integrated neutron flux. Additional tests indicated the change in gain was the result of defect annealing. Test data for a number of different transistor types were given.

The difficulty in interpreting the results of radiation and thermal tests when these are carried out separately was stressed by F. J. Campbell of the U. S. Naval Research Laboratory, who said that life of insulating materials must be measured under a combined thermal and radiation environment.

Such measurements show that radiation exposure can increase the high-temperature life of several materials by 800%, Campbell said. He said this is probably because of a balancing of the chain-scission and cross-linking mechanisms that occur in polymer reactions. Increased life is not, however, obtained with all materials, he added.

Neutron and gamma irradiation of indium arsenide and indium antimonide Hall-effect multipliers indicates that they can be used close to a-c power-conversion systems such as SNAP-8, D. L. Nelson, Research Laboratories division, Bendix Corp. told the conference.

● **Useful tool**—The Hall-effect multiplier offers a simple way to measure average a-c power for telemetry, provided it can stand up to the SNAP radiation environment.

Tests by Bendix showed that effects of gamma radiation (5×10^7R, cobalt-60) were negligible. Neutron doses of 10^{15} nvt caused measurable changes in Hall coefficient, however. Nelson suggested a simple method for compensating for parameter changes caused by radiation, similar to a temperature-compensation technique. This keeps errors in the multiplying constant to less than 1% for InAs devices and less than 3% for InSb devices.

Two InAs devices mounted on glass substrates failed abruptly during neutron exposure. Because of the high radiation activity, these failures were not investigated thoroughly, but they were attributed to mechanical failure of the wire leads or solder connections. ■

beyond apollo—
the U.S. space program

4th annual NASA issue

november 30, 1964



MISSILES AND ROCKETS, the weekly of Space Systems Engineering, will publish its fourth annual NASA Issue on November 30, 1964.

This annual issue, now accepted as the authoritative publication on the nation's space agency, will examine future procurement plans of the National Aeronautics and Space Administration and three organizations allied with it in exploring the peaceful uses of space, Communication Satellite Corporation, Atomic Energy Commission and the U.S. Weather Bureau.

With major procurement for the Apollo manned lunar landing program now behind it, NASA is deep in the planning for new projects to expand man's knowledge of space, including such post-Apollo missions as the Lunar Logistic Supply System, Manned Orbital Research Laboratory, Extended Apollo, Project Voyager and Manned and Unmanned Planetary Probes. ComSat Corp., AEC and the Weather Bureau are drawing up plans for their growing participation in the peaceful use of space.

This issue of MISSILES AND ROCKETS provides the recognized and authoritative route to reach the men who will be making the research, design, engineering | and | procurement decisions in these new multi-billion dollar programs.

bonus circulation

By request, the fourth annual NASA issue of MISSILES AND ROCKETS will provide 5,000 bonus circulation to the decision-makers in NASA, AEC, ComSat Corp. and the Weather Bureau. This means more impact, more readership for your advertising dollars in MISSILES AND ROCKETS.

publication date—nov. 30, 1964

missiles and rockets

American Aviation Publications, Inc., 1001 Vermont Ave., N.W., Washington, D.C. 20005

Missile/Space Facilities

The Communications Satellite Corp. is considering the establishment of a multi-million dollar satellite ground station in eastern Washington state to handle telephone and data signals from satellites. ComSat Corp.'s chief of ground radio engineering, James B. Potts, is presently in that state inspecting possible sites. To meet the operational timetable of 1967, construction on the Washington site will have to begin within the next few months. . . . *Douglas Aircraft Corp.'s Missile and Space Div. is expecting to complete a high energy propellant test facility near the Edwards AFB, Calif., Air Force Propulsion Laboratory by late this year. The $250,000 facility will be among the first of its kind and will be devoted to developing and testing systems, components and handling techniques of advanced, high energy propellants for future space vehicles.* . . . Avco Corp.'s Research and Advanced Development Div., Wilmington, Mass., has accepted delivery of an 18x18x18-ft. stainless steel panelled walk-in environmental test chamber from American Research Corp., Farmington, Conn. The unit contains complete automatic programming control of dry-bulb temperature and relative humidity conditions. Features of the chamber include temperature range from —100°F through 350°F. A 120-hp motor powers the mechanical cascade refrigeration system, which uses freon 13 and freon 22 refrigerants. . . . *Spectrol Electronics Corp., San Gabriel, Calif., manufacturer of precision potentiometers and other electronic components, will soon begin construction of a new plant at City of Industry, Calif. The firm's four California facilities will be consolidated in the 65,000-sq.-ft. building by July.* . . . The Boeing Co. has leased 8,000 sq. ft. of office space in the town of Cape Canaveral, Fla., to keep pace with its expanding missile/space activities in the Cape Kennedy area. . . . *TRW Space Technology Laboratories plans to complete the first of five buildings it is constructing in Houston near NASA's Manned Spacecraft Center. The complex, when finished, will cover 10 acres and provide some 250,000 sq. ft. of floor space.*

Mergers and Acquisitions

Avnet Electronics Corp. and Interphoto Corp., Culver City, Calif., have negotiated a merger agreement, subject to approval by the boards of directors of the two firms and their shareholders. The merger is to be accomplished through a stock transaction. Avnet is a diversified marketing corporation and Interphoto is a leading distributor of cameras and other photographic equipment. . . . *Switchcraft, Inc., Chicago, electrical switch manufacturer, has purchased the production tools, equipment and inventory of Federal Anti-Switch Co., New York City. The Federal line consists of lever-actuated anti-capacity switches, which will complement the lever and push-button switches made by Switchcraft.*

New Activities

Advanced Metals Corp. has been formed in Pittsburgh to produce a wide range of powdered metal components for mechanical and electrical applications. Basic product areas will include electrical contacts, semi-conductor components, electrical discharge machining electrodes and mechanical parts of all types.

Company Representatives

Technical Appliance Corp. (TACO), Sherburne, N.Y., manufacturer of military and industrial antennas, antenna systems and accessory equipment has appointed three new representatives. Earl Associates of Honolulu will serve Hawaii and U.S. Territories and Possessions in the Pacific; the Portland and Seattle offices of Don H. Burcham Co. will be responsible for the states of Alaska, Oregon, Washington, northern Idaho and western Montana. In southern California, southern Nevada and Arizona the Kittleson Co. of Los Angeles will represent the TACO line. . . . *Telonic, Inc., Beech Grove, Ind., has appointed Electro-Sales Assoc. its new sales representative for Michigan, Ohio and western Pennsylvania. Electro-Sales has offices in Dayton, Cleveland, Detroit and Pittsburgh. Telonic makes sweep/signal generators, turret and toggle attenuators, coaxial RF switches and RF detectors.* . . . Texas Instruments, Inc., Dallas has appointed V. Avis McCorvey & Co., Decatur, Ga., its Southeastern sales representative for TI's line of carbon-film resistors. McCorvey will serve Georgia, Alabama, Florida, North and South Carolina and eastern Tennessee.

International

Air Products and Chemicals, Inc., Allentown, Pa., and Societe Generale de Belgique has agreed to form a jointly owned company, Air Products, S.A.-N.V., with headquarters in Brussels. Air Products S.A.-N.V. will build a $7-million oxygen-nitrogen-argon plant near Ghent, Belgium, and will engage in the production, distribution and sale of industrial gases and related gas-using equipment throughout the Benelux countries. The firm will also sell cryogenic process plants within the same market area. . . . *An International Telephone and Telegraph subsidiary, Standard Telephones and Cables (SA) (Pty) Ltd. in South Africa, has completed a production sample run of 15,000 silicon epitaxial transistors in a newly established manufacturing unit. The event was probably the first production run of transistors in Africa.* . . . Amphenol-Borg Electronics Corp., Broadview, Ill., has acquired Amphenol Canada Ltd., Toronto, for an undisclosed amount of cash. Amphenol Canada will continue to make its present line of electrical and electronic components featuring connectors and coaxial cable as a wholly owned subsidiary of Amphenol-Borg.

contracts and procurements

AWARDS

AIR FORCE

$5,506,086—**North American Aviation, Inc.,** Anaheim, Calif., for spare parts for *Minuteman* guidance system.

$2,988,000—**Aerojet-General Corp.,** Sacramento, Calif., for continued work on liquid rocket engines for unspecified space projects.

$2,200,000—**General Precision Equipment Corp.,** General Precision, Inc., Little Falls, N.J., to conduct a flight feasibility test program on an unnamed stellar inertial guidance system.

$1,650,150—**Martin Co.,** Denver, Colo., to update technical manuals for *Titan II* program.

$1,550,000—**North American Aviation, Inc.,** Canoga Park, Calif., for continued manufacture of *Thor* rocket propulsion systems.

$1,500,000—**General Telephone & Electronics Corp.,** Sylvania Electric Products, Inc., New York City, for production of special-purpose electronic receiving equipment.

$1,150,000—**Lockheed Aircraft Corp.,** Sunnyvale, Calif., increment for work on an unspecified space research program.

$114,000—**Martin Co.,** Baltimore, for development of a minimum reactor power hand-tool for use and experimentation in free outer space environment.

$65,246—**Aerojet-General Corp.,** Nucleonics Div., San Ramon, Calif., for controlled fusion propulsion research.

ARMY

$20,600,000—**Philco Corp.,** Aeronutronic Div., Newport Beach, Calif., for mass production of *Shillelagh* gun-launched anti-armor guided missiles.

$1,740,600—**Western Electric Co.,** New York City, for engineering services in connection with Sleigh Ride anti-missile research program.

$1,646,545—**Akwa-Downey Construction Co.,** Milwaukee, for an equipment laboratory test building to be built at Patrick AFB for calibrating and repairing precision measuring equipment and optical items used on the Eastern Test Range.

$1,413,890—**Smith and Sapp Construction Co.,** Orlando, Fla., to build a launch equipment shop to provide machine shop facilities for NASA's Merritt Island Launch Area.

$108,000—**Martin Co.,** Orlando, Fla., for nonpersonal technical services in support of the Army Missile Command and DOD zero-defects program.

NAVY

$16,883,000—**Gyrodyne Company of America, Inc.,** St. James, N.Y., for production of antisubmarine drone helicopters.

$9,573,525—**Lockheed Missiles & Space Co.,** Sunnyvale, Calif., for engineering services, logistic support and technical assistance in support of fleet ballistic missile program.

$6,664,931—**Avco Corp.,** Richmond, Ind., for *Polaris* missile fusing devices.

$2,210,400—**Aerojet-General Corp.,** Sacramento, Calif., to make propellant material for *Polaris* missile motors.

$2,093,750—**North American Aviation, Inc.,** Canoga Park, Calif., for continued work on rocket motors for air-to-ground missiles.

$1,840,895—**Interstate Electronics Corp.,** Anaheim, Calif., for *Polaris* instrumentation.

$79,838—**Goodyear Aerospace Corp.,** Akron, Ohio, for services, material and equipment for evaluation of feasibility of utilizing ballute system as control device for Snake Eye II weapon.

$49,463—**Aerochem Research Laboratories, Inc.,** South Brunswick Township, N.J., for research of rocket exhaust gases phenomena.

NASA

$3,500,000—**Aerojet-General Corp.,** Azusa, Calif., incremental funding for SNAP-8 program.

$1,500,000—**Aerojet-General Corp.,** Sacramento, Calif., for incremental funding liquid rocket operations.

$1,283,617—**TRW/Space Technology Labs, Inc.,** Redondo Beach, Calif., for continuation of guidance and control effort of the *Atlas/Centaur* vehicle studies for a 12-month period.

$1,000,000—**Computer Sciences Corp.,** El Segundo, Calif., for computer programming services.

$582,304—**Missile Systems Corp. of Texas.,** Emtex Div., Carrollton, Tex., for manufacture and assembly of *Talos* guidance, control and airframe booster fins.

$500,000—**Lockheed Missiles & Space Co.,** Sunnyvale, Calif., incremental funding.

$175,000—**Douglas Missile and Space Systems Div.,** Santa Monica, Calif., for parametric study of logistics-type entry vehicles.

$98,539—**North American Aviation, Inc.,** Space and Information Systems Div., Downey, Calif., for a study of unmanned system to evaluate the Martian environment.

$97,625—**Rocket Research Corp.,** Seattle, for development of subliming solid control rocket.

$71,500—**USAF Logistics Command,** Middletown, Pa., for hydrazine and UDMH propellant.

$34,500—**Atomic Energy Commission,** Paducah, Ky., for rocket injector assemblies.

Thiokol Chemical Corp., Wasatch Div., Brigham City, Utah, to determine the feasibility of using beryllium propellant to improve the main retromotor for the *Surveyor* spacecraft (amount undisclosed).

INDUSTRY

$40,000,000—**Martin Company,** Orlando, Fla., from **Bell Telephone Laboratories,** Whippany, N.J., for continued development work on the *Sprint* anti-missile missile.

$5,000,000—**Fairchild Camera and Instrument Corp.,** Semiconductor Div., Mountain View, Calif., from **Control Data Corp.,** Minneapolis, for silicon transistors and diodes.

$1,280,000—**Systron-Donner Corp.,** Concord, Calif., from **General Electric Co.,** New York City, for a quantity of analog computers.

$225,000—**Marquardt Corp.,** Van Nuys, Calif., from **The Boeing Co.,** Seattle, for small rocket engines that will guide lunar orbiter spacecraft around the Moon.

$125,000—**Quantic Industries, Inc.,** San Carlos, Calif., from **Thiokol Chemical Corp.,** Wasatch Div., Brigham City, Utah, to redesign the standardized safety and arming device which is used for ignition of the three propulsion stages of the *Minuteman* missile.

General Telephone & Electronics Corp., Sylvania Electric Products, Inc., New York City, from **American Machine and Foundry Corp.,** New York City, for an order for 29 nuclear fuel elements for the Pakistan Research Center (amount undisclosed).

ITT Federal Laboratories, Fort Wayne, Ind., from **Sperry Rand Corp.,** Univac Div., St. Paul, Minn., for the design and development of a multi-color display system for the Army Pentagon War Room (amount undisclosed).

Super-Temp Corp., Santa Fe Springs, Calif., from **Aerojet-General Corp.,** Sacramento, Calif., for missile nozzle components for the *Polaris A-3* (amount undisclosed).

ARMS CONTROL AND DISARMAMENT AGENCY

$125,628—**Thompson Ramo Wooldridge,** Space Technology Laboratories, Redondo Beach, Calif., for a study of the ways in which ICBM's could be more quickly built and placed for use by a country violating a possible agreement to limit production or by a country responding to such a violation.

REQUESTS FOR BIDS

GENERAL PROCUREMENTS

Purchasing Office
George C. Marshall Space Flight Center
Huntsville, Ala. 35812
Attn: R. W. Clatworthy

Negotiations are to be conducted with Auburn Research Foundation, Auburn University, Ala., for a basic research and developmental type program (study) entitled "Investigation of Optimum Design for dc Operational Amplifiers." For information only; RFP not available.

Purchasing Office
George C. Marshall Space Flight Center
Huntsville, Ala. 35812

Supporting research studies to booster flight control problems to be issued to colleges and universities only. RFQ due date Dec. 3, 1964. It is estimated that the period of performance will be for twelve months.

National Aeronautics and Space Administration
Ames Research Center
Moffett Field, Calif. 94035

Negotiations will be conducted with Lockheed Aircraft Corp., Palo Alto, Calif., for a study to design and develop a water vapor electrolysis unit. For information only; RFP not available.

Directorate of R&D Procurement
Systems Engineering Group
Research and Technology Division
Wright-Patterson AFB, Ohio

Research and development to estatblish design criteria and fabrication techniques for a wide range, thermoelectrically and structurally stable pyrolytic graphite thermocouple of high accuracy suitable for aerospace applications. RFP 5-20150-KNA. Requests for copies of this proposed procurement should be received not later than Nov. 25.

U.S. Army Missile Command
Procurement and Production Directorate
Procurement Operations Office
Systems Contracts Division A
Negotiation Br. 2
Redstone Arsenal, Ala. 35809
Attn: AMSMI-IWB

The U.S. Army Missile Command has awarded Contract DA-01-021-AMC-11549(Z) to The Bendix Corp., Bendix Systems Div., Ann Arbor, Mich., for design, fabrication and installation of TV tracker system. It is suggested that small business firms or others interested in subcontracting opportunities in connection with this procurement make direct contact with the Bendix Corp.

U.S. Army Missile Command
Procurement and Production Directorate
Procurement Operations Office
Systems Contracts Division A
Negotiation Br. 2
Redstone Arsenal, Ala. 35809
Attn: AMSMI-IWB

The U.S. Army Missile Command has awarded Contract DA-01-021-AMC-11565(Z) to Baird-Atomic Inc., Cambridge, Mass., for classified study. It is suggested that small business firms or others interested in subcontracting opportunities in connection with this contract make direct contact with Baird-Atomic.

Lewis Research Center
21000 Brookpark Road
Cleveland, Ohio 44135

Negotiations will be conducted with General Atomics Div. of General Dynamics Corp., San Diego, Calif., for continuation research of thermionic materials for space power applications. For information only; RFP not available.

Lewis Research Center
21000 Brookpark Road
Cleveland, Ohio 44135

Negotiations will be conducted with Electro-Optical Systems, Inc., Pasadena, Calif., for fabrication of ten infiltrated sintered tungsten ionizer slabs for contact ion engine tests. For information only; RFP not available.

Lewis Research Center
21000 Brookpark Road
Cleveland, Ohio 44135

Negotiations will be conducted with Monsanto Research Corp., Dayton, Ohio, for a continuation of a research development & experimental program to design, fabricate and test a fuel cell operating on storable rocket propellants. For information only; RFP not available.

Lewis Research Center
21000 Brookpark Road
Cleveland, Ohio 44135

Negotiations will be conducted with Thompson Ramo Wooldridge Inc., Cleveland, Ohio, for a continuation study to optimize high power static inverters. For information only; RFP not available.

Lewis Research Center
21000 Brookpark Road
Cleveland, Ohio 44135

Negotiations will be conducted with the Franklin Institute, Philadelphia, for an analytical study on the stability of rotors supported on gas bearings. For information only; RFP not available.

Lewis Research Center
21000 Brookpark Road
Cleveland, Ohio 44135

Negotiations will be conducted with S. V. Manson and Co., Inc., Arlington, Va., for a continuation research study on liquid cooled hear exchangers to be used in the evaluation and optimization of the Brayton Cycle for Power Applications in Space. For information only; RFP not available.

Lewis Research Center
21000 Brookpark Road
Cleveland, Ohio 44135

PR was issued on 10-29-64 for a research and development program on applicability of nuclear-thermonics to the production of electric power for space application to General Atomic Division of General Dynamics Corp., San Diego, Calif. 92112, Attn: Mr. Paul C. McWeen, Jr. It is suggested that small business firms or others interested in subcontracting opportunities in connection with this contract make direct contact with Mr. McWeen.

Procurement and Production
R&D Contract Division
Laurence G. Hanscom Field
Bedford, Mass., 01731

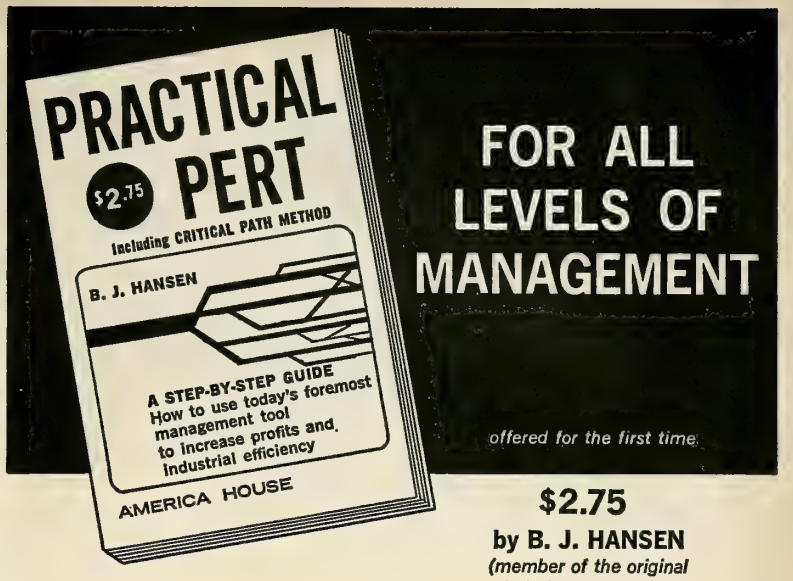
Modification of contract for continuation of research directed toward the study of solar terrestial relationships to be negotiated with Geo-Science, Inc., Alamogordo, N.M. For information only; RFP not available.

National Aeronautics and Space Administration
Ames Research Center
Moffett Field, Calif. 94035

Negotiations are being conducted with American Bosch Arma Corp., Arma Division, Garden City, N.Y., for a space navigation computer study. For information only; RFP not available.

Contracting Officer
National Aeronautics and Space Administration
Langley Station
Hampton, Va.

Request for Proposal L-4947 initiates the Langley Research Center's effort to achieve the objectives of the hypersonic ramjet experiment project. The technical and business management portions of RFP L-4947 due date is Jan. 5, 1965. Price and financial due date is Jan. 19, 1965. Telephone requests should be directed to Hampton, Va., Area Code 703-722-7961/Ext. 3330.



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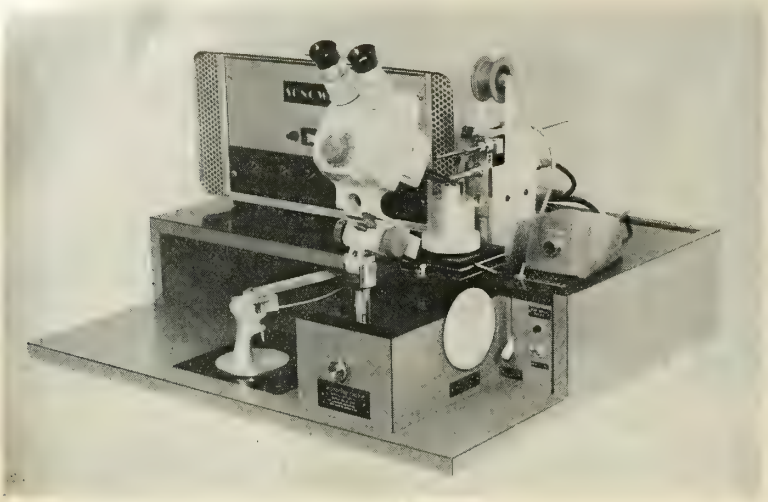
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New Product of the Week: Micropositioner

A complete ultrasonic welding work station, the Model MP-20-L, has been developed by the Sonobond Corp.

The micropositioner is designed for lead-wire bonding to semiconductor devices and for use in microcircuitry. Focus of the unit's design is a 20-watt ultrasonic welding system, said to eliminate problems associated with the heating cycle of thermocompression bonding.

The device provides wire-feed, work manipulation, welder head operation and work positioning. Single-hand operation includes X-Y positioning, welder-head lowering, clamping-force application, weld-cycle initiation, head lift and wire feed. A single right-hand wheel control is used for the Z position (adjustable to two positions). Vacuum or mechanical chuck pedestals (rotational 360 degrees) are available.

Circle No. 151 on Subscriber Service Card

Square Function Generator

A signal-operated square function generator requiring no power supply is being marketed by Scientific Columbus, Inc.

The Model M-500ST has an input range of 0 to 500 ma peak. Nominal output at 250 ma is 100 mv. The device is temperature-compensated from −55° to 75°C and has an accuracy of ±1%. Input and output are solder terminals in a glass-to-metal sealed header. The unit measures 1.75 x 1.25 x 2.75 in.

Circle No. 152 on Subscriber Service Card

Electronic Welder

Unitek's Weldmatic Div. is marketing a capacitor-discharge welder power supply featuring an SCR discharge circuit. The solid-state Model 1059BMS also features full circuit switching for each of two ranges. Low range is 0.06 to 9 watt-seconds; high range is 0.3 to 45 watt-seconds.

Output energy is maintained within ±1% for line voltage variation between 100 and 130v ac. Discharge time is 0.0025 second into 1-milliohm load.

Circle No. 153 on Subscriber Service Card

Phase-Angle Voltmeter

North Atlantic Industries, Inc., is marketing a three-frequency phase-angle voltmeter. Measurement capability includes operation as a conventional VTVM from 10 cps to 100 kc. As a





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phase-angle voltmeter, channels are available for any of three frequencies from 30 cps to 20 kc, all ±5% bandwidth without adjustment. Phase-sensitive null sensitivity exceeds 1.0 microvolt. All functions operate over 13 ranges, 300 mv to 300v full scale.

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Vibration Exciter

MB Electronics has introduced a vibration exciter with a lightweight moving element designed to permit higher payloads and forces than previous units.

The Model C21 is engineered for both light-load high-g testing and heavy-load low-g testing. It produces a 2,000-lb. vector force (4,200-lb. peak) and has a usable frequency range of 5 to 5,000 cps at a maximum acceleration of 125 g's. At full-force operation, a payload of 10.8 lb. can be driven to 100 g or 190 lb. to 10 g.

According to the firm, the design of the moving element also gives the unit an inherently high natural frequency, with the first disturbing resonance ocurring above 3,800 cps at no load. Loaded resonant frequency is usually 0.7 of the unloaded resonant frequency for maximum loads.

Circle No. 155 on Subscriber Service Card

Trace Sampler

The "EEL" spectra, manufactured by Evans Electroselenium, Ltd., is a self-contained instrument that gives colorimetric determinations of trace elements in solid samples.

It incorporates a continuous spectrum-wedge optical filter and a single photocell to provide wavelength measurements from 400 to 700 millimicrons. Up to four samples may be inserted, thus permitting a check on both standard and blank solutions.

Information is available from Borders Electronics Co.

Circle No. 156 on Subscriber Service Card

Klystron Amplifier

An electrostatically focused klystron amplifier for space communications and tracking has been developed by Electron Tube Div. of Litton Industries, Inc.

The L-3910 is a 32-oz., S-band, all-metal-ceramic microwave tube. It delivers a nominal power output of 20 watts CW at 2,287.5 mc. Power level can be varied from 5 to 50 watts at good efficiency by varying the beam voltage, the company says. At the 20-watt power level, beam voltage is 1,650v, nominal efficiency is 30% (without a depressed collector), gain is 20 db, bandwidth is 5.5 megacycles and noise figure is 28 db.

Circle No. 157 on Subscriber Service Card

Impedance Meter

Dranetz Engineering Laboratories, Inc., is marketing a complex impedance admittance meter which makes possible direct measurement and continuous locus plotting of parallel equivalent conductance and susceptance for an unknown having one terminal grounded.

The Model 100B is designed to avoid circulating ground currents during measurements, particularly important in low-level calibration of sonar and ultrasonic transducers.

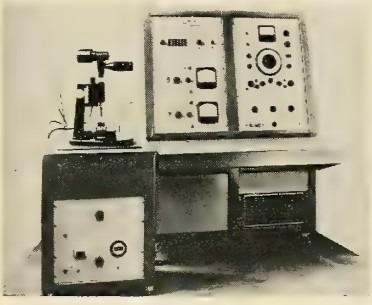
Specifications include 12 full-scale admittance ranges from 10 micromhos to 50 millimhos; a frequency range of 100 cps to 200 kcps and voltage across unknown, 3v RMS.

Circle No. 158 on Subscriber Service Card

Calibration System

A calibration system which offers absolute calibration of accelerometers at frequencies up to 50 kc and measurement of small dynamic displacements has been developed by Gulton Industries, Inc.

The Model KA-2826 has a wave form distortion of less than 2% to



20 kc and 5% to 50 kc. It is composed of an interferometer, piezoelectric vibrator and driver. The interferometer has a frequency range of 500 cps to 50 kc and can measure absolute displacements from 4×10^{-6} to 45×10^{-6} in. Set-up time is less than 5 minutes.

Circle No. 159 on Subscriber Service Card

Ultrasonic Cleaner

A multi-purpose ultrasonic system for removal of inorganic and organic dirt from precision components is being marketed by Blackstone Ultrasonics Corp.

The duel-tank unit pre-cleans ultrasonically in heated solvent in one tank. The other tank heats the solvents, condenses vapors, ultrasonically washes, filters solvents, spray rinses and vapor rinses. The system consists of a heated wash unit with a transducer, a heated and cooled wash/rinse unit with transducer, a filtered spray flushing unit and a generator. A double output receptacle and selector switch on the generator permits the operator to activate either tank.

Circle No. 160 on Subscriber Service Card

Field Effect Amplifier

A field effect amplifier with a transconductance exceeding 1 mho has been



introduced by Raytheon Co.'s Semiconductor Div.

The Mho-Amp has a total device dissipation of 5 watts and a gain of 150 db. Input impedance is greater than 10^{15} ohms, excluding external circuitry. Noise figure is less than 2 db at 1 kc with a generator impedance of one megohm.

Circle No. 161 on Subscriber Service Card

Coated Resistor Line

Electra Manufacturing Co. has developed a line of conformally coated resistors—engineered to achieve a failure rate of no more than 0.0004% per 1,000 hrs.

The CHM line is available in five sizes with a combined resistance range from 30.1 ohms to 1 megohm. The resistors are rated at 1/20, 1/10, 1/8, 1/4 and 1/2 watt, all at 125°C. Resistance tolerance of the 1/20-watt unit is 1%.

Circle No. 162 on Subscriber Service Card

Silicone Rubber Base

Silicone rubber compounds designed to contain large amounts of extending fillers while retaining good physical properties can be produced from a new compounding base, according to Dow Corning Corp.

Designated Silastic 437 base, the material is designed for use in compounding rubbers for MIL-R-5847D, IIa and IIb, classes 40 to 80; MIL-STD-417 TA 405, 805, 407, 807; and AMS 3301 to 3305 specifications.

The material consists of 81% (by weight) methyl vinyl polysiloxane and 19% reinforcing silica filler. Typical properties include a specific gravity of 1.09 and a brittle point of —100°F.

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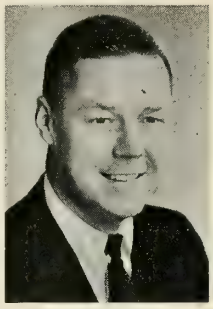
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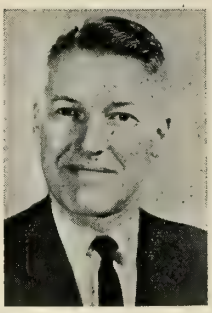
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names in the news



COUCH



VAUGHN



SKEEN

Named to newly created corporate group vice presidential posts at Aerojet-General Corp. are **L. W. Mullane,** formerly corporation vice president and general manager; and **Dr. A. L. Antonio,** vice president, who recently served in Aerojet's Sacramento plant and its Space-General Corp. subsidiary in El Monte, Calif.

Clyde Skeen: Elected president of Ling-Temco-Vought, Inc., Dallas. He was formerly executive vice president and chief financial officer at LTV. Skeen succeeds Gifford K. Johnson, who resigned.

William D. Kiehle: Elected national president of the Society for Non-Destructive Testing for 1964-65. He is manager of industrial X-ray sales for Eastman Kodak Co., Rochester, N.Y. Other officers elected were **Bryant E. Justice,** General Dynamics Corp., vice president; **Richard B. Socky,** General Electric Co., treasurer; and **Philip D. Johnson** of the society, secretary.

George J. Bohrer: Appointed director research and development, friction materials, of the Thermoid Division of H. K. Porter Co., Inc., Pittsburgh.

Robert B. Young: Has returned to his position as vice president and general manager of Aerojet-General Corporation's Sacramento Plant in California. He served as a top deputy to Dr. Wernher von Braun during the past year at NASA's George C. Marshall Space Flight Center, Huntsville, Ala.

Richard W. Couch: Appointed vice president and general manager of the eastern operation of Sylvania Electric Products, Inc., Electronic Systems Division, New York City. He was formerly manager of the division's *Minuteman* program. **Harvey S. Tzudiker** has been named manager-technical liaison for the European Area of Sylvania.

Thomas F. Russell: Elected vice president-finance for Federal-Mogul-Bower Bearings, Inc., Detroit.

Frank W. Vaughn: Appointed manager and director of the Merritt Island launch-support services for the Bendix Field Engineering Corporation, Cape Kennedy, Fla. He will deal basically with the operation of Launch Complex 39—the center of launch activities for the *Apollo-Saturn V.*

M. E. Ellion: Appointed associate manager of the space systems division Propulsion Department of Hughes Aircraft Co., Culver City, Calif. He was formerly a consultant to many of the nation's major missile programs. **Robert B. Robinson** was named manager of power systems and test operations, space systems. He was formerly with Boeing Co. working on *Minuteman* support.

Jay A. Erikson: Joined U. S. Polymeric Chemicals, Inc., Santa Ana, Calif., as a research and development staff scientist.

Warren C. Anderson: Appointed president of Micro Systems, Inc., a subsidiary of Electro-Optical Systems, Inc., Pasadena, Calif. He was formerly president and treasurer of Graham Engineering.

John N. Howard: Named to fill the newly created post of chief scientist at Air Force Cambridge Research Laboratories AF/OAR), Cambridge, Mass. He will advise the AFCRL commander on existing and planned research programs in the physical and environmental sciences.

J. H. Mann: Appointed assistant to the president of Ace Electronics Associates, Inc., Somerville, Mass., a manufacturer of precision potentiometers for electronics, missile and space industries.

Thomas J. Hanratty: Recipient of the William H. Walker Award from the American Institute of Chemical Engineers for excellence in contributions to chemical engineering literature.

Joseph C. Brenner: Elected president of Astro Space Laboratories, Inc., Huntsville, Ala. He has been vice president and general manager of this subsidiary of Belock Instrument Corp. for the past year.

James C. Fletcher: Inaugurated president of the University of Utah, Salt Lake City. He was formerly chairman of the board of Space-General Corp., El Monte, Calif., and systems vice president of Aerojet-General Corp., Azusa, Calif.

E. J. Brandt: Appointed general manager of Hopkins Engineering Co., Los Angeles, manufacturers of capacitors and RFI filters, and subsidiary of Maxson Electronics Corp.

—when and where

NOVEMBER

Third International Symposium on Bioastronautics and the Exploration of Space, sponsored by the Aerospace Medical Div., Air Force Systems Command, Brooks AFB, Tex., Nov. 16-18.

Annual Meeting of the Association of the U. S. Army, Sheraton Park Hotel, Washington, D. C., Nov. 16-18.

Symposium on Microelectronics and Large Systems, sponsored by the Office of Naval Research and the Univac Division of Sperry Rand Corp., Dept. of Interior Auditorium, Washington, D.C., Nov. 17-18.

Tenth Anniversary Tri-Service Conference on Electromagnetic Compatibility, sponsored by IIT Research Institute, Museum of Science and Industry, Chicago, Nov 17-18.

Value Engineering Symposium for Advancement in the State-of-the-Art, sponsored by the Army Missile Command, Rocket Auditorium Redstone Arsenal, Ala., Nov. 18-19.

Northeastern States Navy Research and Development Clinic, sponsored by the Franklin Institute, Philco Corp., Temple University, the University of Pennsylvania, the Office of Naval Material, and the National Security Industrial Asosciation, and others, Philadelphia, Nov. 18-20.

Sixteenth Annual MAECON Technical Meeting, Continental Hotel, Kansas City, Mo., Nov. 23-24.

Winter Annual Meeting of the American Society of Mechanical Engineers, Statler Hilton Hotel, New York City, Nov. 29-Dec. 4.

Joint Meeting of the American Nuclear Society and Atom Fair, Hilton and St. Francis Hotels, San Francisco, Nov. 30-Dec. 3.

DECEMBER

57th Annual Meeting of the American Institute of Chemical Engineers, Statler Hilton Hotel, Boston, Dec. 6-10.

Third Conference on Performance of High Temperature Systems, Huntington-Sheraton Hotel, Pasadena, Calif., Dec. 7-9.

Third Annual Western Contamination Control Congress, sponsored by the Western Regional Chapter of the American Association for Contamination Control, Lafayette Hotel, Long Beach, Calif. Dec. 9-11.

131st Annual Meeting, American Association for the Advancement of Science, Boston, Mass., Dec. 26-31.

JANUARY

Eleventh National Symposium on Reliability and Quality Control, sponsored by the American Society for Quality Control, and Institute of Electrical and Electronics Engineers, Fontainebleau Hotel, Miami Beach, Jan. 12-14.

International Symposium on Solar Radiation, sponsored by the American Society for Testing and Materials, International Hotel, Los Angeles, Jan. 18-21.

Winter Meeting of the National Society of Professional Engineers, Jung Hotel, New Orleans, Jan. 20-23.

National Symposium on Hydrocarbon Analysis sponsored by the American Society for Testing and Materials, Sheraton-Lincoln Hotel, Houston, Jan. 22-23.

Symposium on Fundamental Phenomena in the Material Sciences sponsored by the Ilikon Corp., Sheraton Plaza Hotel, Boston, Jan. 25-26.

Joint Annual Meeting of the American Mathematical Society and the Mathematical Association of America, Univ. of Colorado, Denver, Jan. 25-30.

FEBRUARY

Reinforced Plastics Division Conference, sponsored by the Society of the Plastics Industry, Edgewater Beach Hotel, Chicago, Feb. 2-4.

Winter Convention on Military Electronics, sponsored by the Institute of Electrical and Electronics Engineers, Ambassador Hotel, Los Angeles, Feb. 3-5.

Unmanned Exploration of the Solar System, sponsored by the American Astronomical Society, American Geophysical Union, American Institute of Biological Sciences, Institute of Electrical and Electronics Engineers, the American Institute of Aeronautics and Astronautics, and the American Astronautical Society, Denver Hilton Hotel, Denver, Feb. 8-10.

Spring Meeting of the American Society for Testing and Materials Statler-Hilton Hotel, Cleveland, Feb. 8-12.

1965 Electrical and Electronic Trade Show, sponsored by the Electrical Representatives Club and the Electronic Representatives Assn., Denver Auditorium Arena, Denver, Feb. 15-17.

MARCH

Symposium on High-Speed Testing, sponsored by Massachusetts Institute of Technology and Brooklyn Polytechnic Institute, Sheraton Plaza Hotel, Boston, March 8-9.

Aviation and Space Conference, sponsored by the American Society of Mechanical Engineers, Statler Hotel, Los Angeles, March 14-18.

International Convention of the Institute of Electrical and Electronics Engineers, New York Hilton Hotel and New York Coliseum, New York City, March 22-25.

Symposium on Thermophysical Properties, sponsored by the American Society of Mechanical Engineers, Purdue University, Lafayette, Ind., March 22-26.

Spring National Convention of the Society for Nondestructive Testing, Los Angeles, March 22-26.

Optical Society of America Meeting, Statler Hotel, Dallas, March 31-April 2.

APRIL

International Symposium on Fission Product Release and Transport Under Accident conditions, sponsored by the Oak Ridge National Laboratory, Oak Ridge, Tenn., April 5-7.

1965 Annual Region III Meeting of the Institute of Electrical and Electronics Engineers, Robert E. Lee Hotel, Winston-Salem, N. C., April 6-8.

1965 Annual Region VI Confernce of the IEEE, Las Vegas, Nev., April 13-15.

Symposium on System Theory, sponsored by Polytechnic Institute of Brooklyn, IEEE, Society for Industrial and Applied Mathematics, AFOSR, ONR and the Army Research Office, New York City, April 20-22.

Southwestern Conference and Electronic Show, sponsored by the IEEE, Dallas Memorial Auditorium, Dallas, April 21-23.

Sixth Symposium on Engineering Aspects of Magnetohydrodynamics, sponsored by the University of Pittsburgh and the Carnegie Institute of Technology, University of Pittsburgh, Pittsburgh, April 21-23.

1965 London International Engineering Exhibition, sponsored by the London Chamber of Commerce, the British Mechanical Engineering Federation, and the British Electrical and Allied Manufacturers' Assn., Olympia and Earls Court, London, April 21-30.

Western States Spring Meeting of the Combustion Institute, Los Angeles, April 26-27.

Institute of Environmental Sciences Meeting, Sherman, House, Chicago, April 26-28.

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The Price of the Future

MILITARY RESEARCH and development in the U.S. is being slowly strangled by the concept which demands the fulfillment of requirements and missions as grounds for substantial expenditure.

An economy-minded Pentagon administration, taking the short-range and short-sighted view, fails to see merit in expensive projects for which immediate military requirements cannot be defined.

It is true, as Pentagon administrators have assured us, that there is funding available for any number of "blue sky" research projects probing the outer boundaries of science and technology. What is not so often pointed out is that these are most frequently projects which can be handled under a $50,000 or $100,000 study contract.

Let one of these projects lead into an expensive hardware program—not as a candidate for advanced development, but still seeking the "blue sky"—and immediately the question of requirements is raised.

The yardstick then becomes one not of potential but of finance. The requirements screen is one behind which the economy axe can conveniently be wielded.

We certainly do not suggest that there should be no responsible fiscal control of research and development. But money should not in every case be the ruling factor.

The airplane, the electric light, the gasoline engine, the telephone—all were brought into being with funds that were scant by today's standards. If a multi-million dollar test program had been needed to prove out any one of these, it would have remained an idea unborn. Yet in today's complex technology, it may cost hundreds of millions of dollars to come up with a development as far-reaching as any one of these.

For current accomplishment, we must be prepared to pay current prices. We must be willing to invest millions in the complex developments that require millions.

Not every project will require this. A major stride forward may come from a $50,000 study contract. A $100-million test program may lead nowhere.

Losses must be regarded as acceptable for it would take a Solomon to know one from the other. There is no guarantee of being on the right track in this business, as perhaps best characterized by the hilarious sketch of Thomas Alva Edison shouting "hello" at his new light bulb.

The Pentagon leadership must be prepared to recognize and acknowledge the need for these financial losses, not as waste, but as the price of progress, and to explain the necessity frankly to Congress and the public.

Instead, Dept. of Defense officials, bound in a mental straitjacket of cost accounting, continue to demand that each project which calls for major expenditure be confronted with the question of missions and requirements. In the face of such a question, there would have been no airplane, no electric light, no gasoline engine, no telephone.

We repeat that we are in favor of sound financial management. But it must allow leeway for the unknown. Questions about missions and requirements should be forbidden in the research and early development stage and allowed when appropriate—prior to production decisions.

The question for R&D projects, particularly expensive ones, is whether they offer promise of a broad range of potential uses or exploration of an unknown area of promising technology. If the answer is yes, then the project should proceed even if it means a costly flight-test program.

"Show me what it will do" will only strangle the R&D effort in a noose labeled state of the art.

ATOMIC ENERGY COMMISSIONER James T. Ramey, disturbed by cutbacks in the SNAP, *Rover* and Pluto programs, makes this point well in an article in the current *Bulletin of the Atomic Scientist:*

"The most important step we can take in that direction is to establish the principle that developers should carry promising developments through the demonstration stage, including flight testing where aerospace activities are involved. This approach provides a potential user with a clear-cut basis on which to make an intelligent decision with respect to specific missions. Meaningful cost analyses are made possible through the practical demonstration of technology, and the elimination of stop-and-go project management can cut waste in expensive technology. I am glad to say that the AEC and NASA subscribe to this general principle."

Significantly, he omits the Dept. of Defense.

"In seeking greater freedom to move ahead with important projects which have much to offer the future of this country," says the AEC commissioner, "we must also demonstrate our willingness to be very selective in choosing them, and to be very forthright in cutting back or canceling those that get on the sick list. Budget requests cannot afford to be burdened with monies for projects which become stalled and cannot achieve their objectives."

This is a liberal, fiscally responsible research and development philosophy which the Dept. of Defense would do well to consider.

William J. Coughlin

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Exploration of the universe by spacecraft capable of safely transporting men takes vast down-to-earth preparation. To accomplish this, Douglas has built what may well be the most advanced company-owned space complex in the world, the Douglas Space Systems Center. Here, in 11 buildings containing the most modern equipment—including a space simulation chamber 39 feet in diameter capable of housing a complete manned spacecraft—work is going forward on huge space programs. In advanced development is the *Saturn* S-IVB, the 58 foot long Douglas stage which will power the three *Apollo* astronauts from earth orbit to moon orbit.



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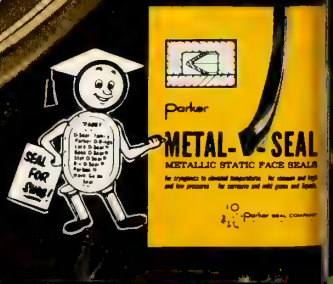
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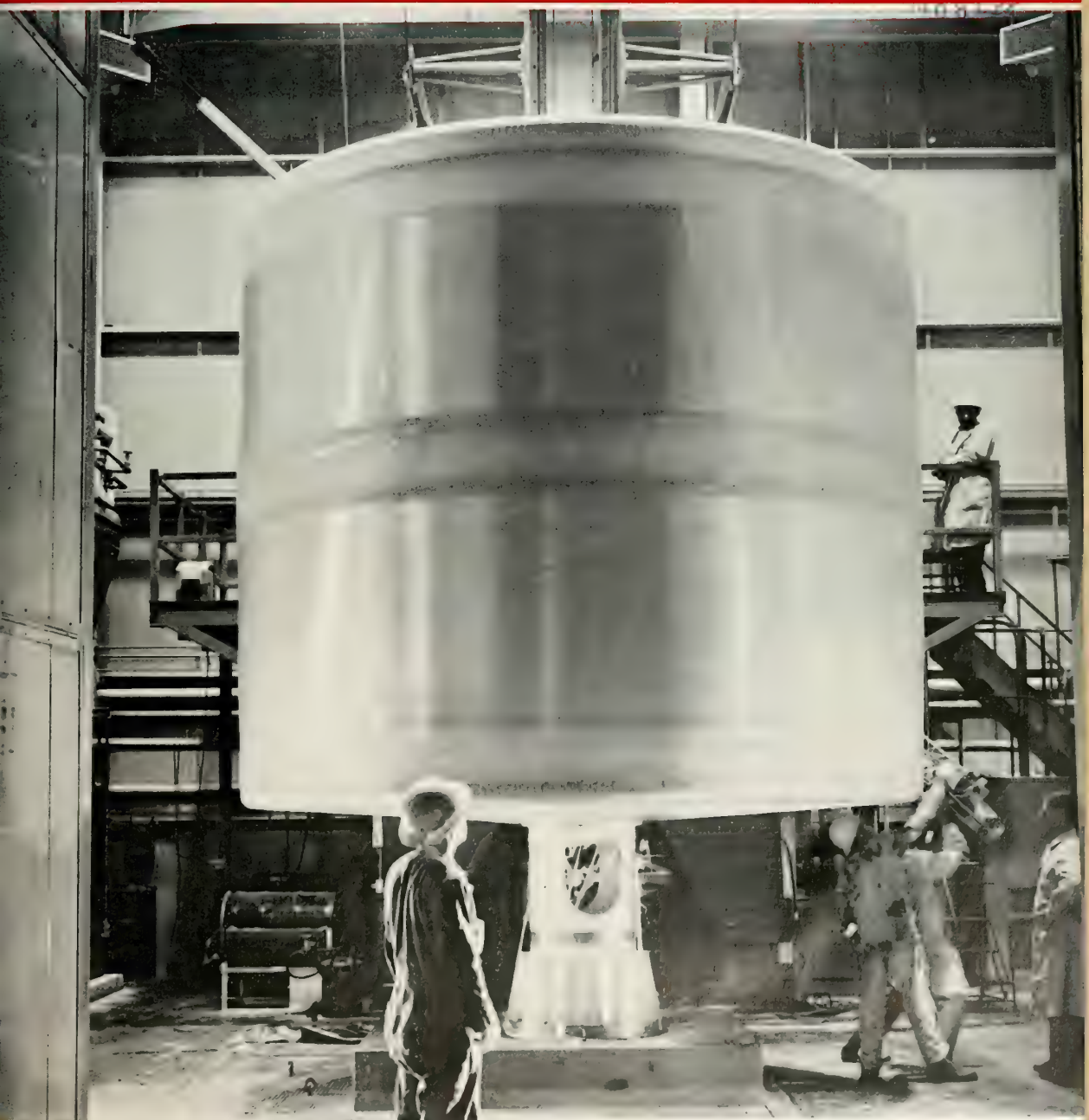


NOVEMBER 23, 196

missiles and rockets

THE WEEKLY OF SPACE SYSTEMS ENGINEERING

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World's Biggest Glass Filament-Wound Structure

AUSA Gets First Public Sprint Display . . .

Soviets See Helium Use in Spaceships . . .

AF Pushes Work on IC Exploitation . . . . . .

NATIONAL RANGE DIVISION

The critical combination: management skills with superior engineering talents

One of the most crucial of Air Force space programs is the testing of missile and vehicle launch and flight procedures. To accomplish this, complex facilities have been developed in many parts of the world. Managing this widespread program calls for an unusual melding of technical capability and executive proficiency.

The organization charged with carrying out this vital responsibility is the National Range Division, operating under the Air Force Systems Command. This new and growing group, staffed with a dedicated civilian-military team, is seeking systems oriented engineers for key positions.

The National Range Division is responsible for planning, developing, operating, maintaining, and controlling all Department of Defense range and flight test facilities in support of National missile and space programs. These facilities include the Eastern Test Range and the Western Test Range in addition to remote support sites around the world which provide key links in tracking, command, telemetry, and communications.

The following disciplines are representative of those in which the National Range Division seeks qualified scientists and engineers. These rewarding positions are presently available in the Career Civil Service.

SUPERVISORY ELECTRONIC ENGINEERS (OPERATIONS)— Supervises the work of a sizeable personnel force engaged in global range control matters involving problems of an operational nature, schedule conflicts, performance standards and operational resource allocations. Supervises the review of range user requirements, resolves conflicts on all operational matters including frequency allocations, range safety, communications, and other support services. Represents the Commander in discussion and negotiations with foreign governments. Provides basic policy and guidance in Global Test Support Configuration and Control Matters.

SUPERVISORY ELECTRONICS ENGINEERS (RANGE SYSTEMS MANAGEMENT)— Supervises a sizeable personnel force in the preparation, identification of equipment deficiencies, consolidation and submission of planning and budgetary documents, establishment of priorities, allocation of funds, proposal review, system acquisition and other tasks relating to global range systems improvement. Represents the Commander in reviews of all instrumentation planning documentation. Provides basic policy and guidance in instrumentation system planning and acquisition.

ELECTRONIC ENGINEERS (COMMUNICATIONS)— Requires system experience in communications electronics, data handling and processing of aircraft and ships' functional areas. Reviews range user requirements, identifies deficiencies and develops design criteria for new instrumentation systems which will correct deficiencies. Responsibilities apply to instrumentation areas of timing, range safety, data handling, data processing, optics, communications, and aircraft and ships. Reviews Research and Development proposals. Directs the efforts of the subordinate test ranges. Reviews system acquisition status.

ELECTRONIC ENGINEERS (SYSTEMS PLANNING)— Requires systems planning experience in trajectory measurement, telemetry, optics, command and control or general instrumentation support. Prepares, reviews, coordinates and revises long range equipment and financial plans and programming documents. Interprets objectives and policies and provides guidance to subordinate test ranges in preparation of plans and studies. Determines the relative priority of various plans and optimizes allocation of monetary resources.

ELECTRONIC ENGINEER (TEST SUPPORT)— Serves as primary liaison officer with missile and space program agencies to identify and discuss instrumentation requirements. Provides guidance and policy to these agencies in documentation of requirements. Reviews and recommends acceptance of range user requirements. Represents the Commander in conferences discussing range user and National Range Division support relations. Compares overall requirements with existing instrumentation equipment to determine support capabilities, reviews instrumentation plans to determine consistency with program needs.

If interview inconvenient, send résumé and/or application for Federal Employment (SF-57) in complete professional confidence to:

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THE WEEKLY OF SPACE SYSTEMS ENGINEERING

Volume 15, Number 21 November 23, 1964

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Published each Monday with the exception of the last Monday in December by American Aviation Publications, Inc., 1001 Vermont Ave., N.W., Washington, D.C. 20005. Cable Address: AMERAV.

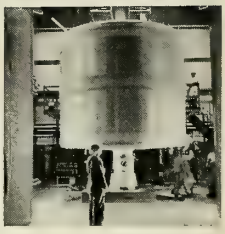
Printed at Judd & Detweiler, Inc., Washington, D.C. Second class postage paid at Washington, D.C.

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Subscription rates: U.S. and Possessions, Canada, and Pan American Postal Union Nations: 1 year, $5.00, 2 years $8.00, 3 years $10.00. All other foreign: 1 year $15.00, 2 years $25.00, 3 years $35.00. Air freight to Europe: 1 year $20.00, 2 years $30.00, 3 years $40.00. Single copy prices: regular issues 50 cents each; special issues $1.00 each. Subscriptions are solicited only from persons with identifiable commercial or professional interests in the missile/space industry. Subscription orders and changes of address should be referred to Circulation Fulfillment Mgr., Missiles and Rockets, 1001 Vermont Ave., N.W., Washington, D.C. 20005. Allow 4 weeks for change to become effective and enclose recent address label if possible.

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THE COVER



Section of glass filament-wound case being fabricated for Thiokol 156-in. solid engine by B. F. Goodrich Aerospace and Defense Products plant in Akron, Ohio. The case when finished will be 50 ft. long and will contain some 20,000 lbs. of glass filament and resin. The 156-in. program is being funded by Air Force Systems Command.

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47,700 copies this issue

letters

Thiokol's Paper Rocket Parts

To the Editor:

Re M/R's July 20 (p. 28) article under "Advanced" Materials, "Thiokol Motor To Test Paper as Low-Density, High-Strength Laminate."

I read this article with mixed emotions —pleasure on one hand that work was being done in this direction and dismay on the other hand that U.S. tax dollars were being spent on "Re" search, rather than Research. Only the material application approaches being "new."

In 1941-42 McDonnell Aircraft performed considerable research work on oriented fiber paper-base laminates. This was Air Force-sponsored and the U.S. Forest Products Lab at Madison, Wis., made substantial contributions. Some substantial number and variety of weapons parts found their way into World War II as a result of this joint effort. Your figures do not indicate a significant improvement over the 20-year-old materials which, incidentally, used Bakelite resins capable of polymerization at low pressures.

If the Dept. of Defense and Industry truly wish to reduce costs in both R&D and production, a great many "old" materials, methods and processes should be reviewed before costly, time-consuming "new" programs are embarked upon. Actually, a number of information agencies are now funded by the Government. Should they not be more extensively used?

C. F. Marschner
Marietta, Ga.

Thiokol's recent work, in which the application approaches most certainly are "new," was done entirely with company funds and didn't cost a single tax dollar. —Ed.

Laser for Density Measure

To the Editor:

Ref: M/R, Oct. 26, p. 23.

Your item concerning the use of a laser in a density-measuring system was very interesting. Cornell Aeronautical Laboratory has been experimenting with such a system since 1962. Results to date are encouraging, and projected work includes the utilization of non-linear optical effects.

J. F. Newton
Research Physicist
Hypersonic Tunnel Department
Cornell Aeronautical Laboratory, Inc.
Buffalo, N.Y.

Military and Moon

To the Editor:

Quite a good military case for manned Moon flight can be made.

The Moon, being by far the nearest celestial body, is well-suited for developing the engineering and technological skills for manned space flight in the Solar System. These skills may be used for military and non-military purposes. The Moon is a very good launching site for missiles and spacecraft because of its ⅙ Earth gravity. This means that the Moon has an escape velocity of 1.47 miles per second, compared with the Earth's escape velocity of 7.0 miles per second. The Moon has little or no atmosphere to hinder the flight of space vehicles as does our planet.

Interception of missiles launched from the Moon might be quite difficult if the interception were limited to that which could be directed from Earth without lunar flight capability. Interception might not be too difficult if the missiles or spacecraft were to proceed in a relatively straight line from the Moon to the Earth. However, the missiles could proceed from the Moon on a highly curved trajectory to any place on Earth. This means that if the missiles were to be detected a sphere with a radius of about a quarter of a million miles (with Earth at the center) would have to be searched by radar all the time!

This is roughly 65 quadrillion cubic miles—quite a bit of space. With a Moon base or spacecraft near the Moon it would be much easier to detect and intercept missiles launched from anywhere on the Moon. Activity on the side of the Moon that never faces Earth could be watched.

Without manned spaceflight, developed by lunar spaceflights like *Apollo*, we will have little freedom of space.

David W. Johnston
Washington, D.C.

Future Lies Ahead

To the Editor:

Now that the election is behind us, and the most unedifying and uninformative campaign debate on record, perhaps the U.S. will settle down to business in space.

The great bipartisan wash of platitudes obscured the space program along with everything else.

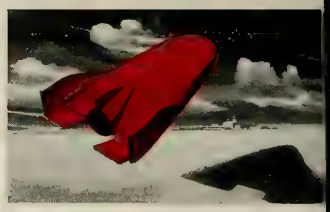
Frank Gregory
Detroit

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Maneuverable return-from-orbit vehicle

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Studies of maneuverable return-from-orbit re-entry vehicles are the most recent of a nine-year series of tough re-entry problems to be examined and solved by General Electric Re-entry Systems Dept. experts. Designs of this type will lead to the eventual development of operational re-entry systems that make precision landings. This work is a natural outgrowth of G.E.'s current Maneuvering Ballistic Re-entry Vehicle Program for the U.S. Air Force.



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RVX re-entry vehicle

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Re-entry Systems Dept., Missile and Space Division, General Electric Co., Phila. 1, Pa. 162-09

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Twenty-two liquid hydrogen RL-10 engines have been fired in space successfully.

Pratt & Whitney Aircraft RL-10 rocket engines have successfully powered both Centaur space vehicles and Saturn SIV stages on flights from Cape Kennedy. All 22 of these rugged space engines fired so far performed precisely as scheduled without a failure. The RL-10, the world's first successful liquid hydrogen rocket engine, was designed and developed for NASA's Marshall Space Flight Center by Pratt & Whitney Aircraft's Florida Research and Development Center. Other advanced rocket fuels are under intensive investigation at the Center where capability extends beyond current space propulsion requirements.

Pratt & Whitney Aircraft DIVISION OF UNITED AIRCRAFT CORPORATION

EAST HARTFORD, CONNECTICUT AND WEST PALM BEACH, FLORIDA

The Countdown

WASHINGTON

AF To Seek Satellite Interceptor

Industry will be asked to submit proposals before the end of the year for what is described by Air Force officials as a new satellite interceptor program. RFP's are classified to guard against revelation of state of the art. The system is expected, however, to go beyond the *Nike-Zeus* and *Thor-Delta* systems now set up in the Pacific.

MAW To Use Bipod Launcher

Because of its high acceleration and short flight time, at least one version of the *MAW* antitank weapon will use a bipod on the front of the launcher. This will steady the launch tube so that movements of the gunner will not throw the missile off target.

Honest John Is in Demand

Under the Army's air assault division concept, the number of *Honest John* launchers is increased to 12—three times the number in the ROAD division. Deciding factor is the firepower deliverable for weight and range.

Gemini Officials Deny Slippage

Project Gemini officials deny continuing reports that the unmanned *GT-2* flight is slipping into early 1965. Target date, they say, still is the first week in December. Full systems checking will begin at Cape Kennedy this week.

Mahon Sees No Drop in Spending

Rep. George Mahon (D-Tex.), new chairman of the House Appropriations Committee, says he expects Federal research and development spending to remain at the $15-billion level, despite a report to the contrary by the House Research Investigating Committee. He also foresees no drop in current Dept. of Defense spending level of $50 billion.

NASA Shows Interest in Sun Probe

NASA officials are interested in an MIT-proposed Sunblazer project, which would employ a high-energy rocket to send a 15-30-lb. payload on missions toward the Sun. Proposal now is being studied by the agency's solar physics subcommittee.

Rumors of TFX Slash Are Unconfirmed

Continuing industry rumors that the Navy buy of the controversial F-111 may be cancelled are not confirmed by project officials. Such a cancellation would, of course, be a political bomb for Secretary of Defense McNamara with the TFX investigation still incomplete.

STINGS Program Moves Forward

Acceptance testing has been completed of the first special test system for the stellar inertial guidance system, originally planned for the *Mobile Medium-Range Ballistic Missile* but now just a feasibility flight program. The test system will be used to evaluate performance of the guidance system during boost and in space. Further environmental testing still is to be conducted.

INDUSTRY

Scramjet Test Is a Success

First successful demonstration of internal thrust from a "scramjet" (supersonic combustion ramjet) has been achieved by General Applied Sciences Laboratories for the Air Force Aeropropulsion Lab at Wright-Patterson AFB. A simulated speed six times that of sound was achieved. Scramjet engines, which are expected to have application in hypersonic vehicles, differ from conventional engines in that the fuel is burned in a supersonic air stream to provide thrust.

Lockheed Briefs Marshall on Solids

A team from Lockheed Propulsion Co. paid a visit to Marshall Space Flight Center last week to brief scientists there on possible use of a 156-in. solid motor as a strap-on for the first stage of both *Saturn 1B* and *Saturn V*. Visit was at the invitation of center director Dr. Wernher von Braun.

Air Force To Test Ladar

Modification is under way on a telescope operated by Lincoln Labs at Wallops Station, Va., to test a "ladar"—a laser radar system. Accurate positioning of satellites using a "Q-switched" laser beam to illuminate the vehicle is expected to result from the experiment.

Boeing Wins Recovery Contract

Manned Spacecraft Center has awarded a $200,000 contract to the Boeing Co. to study recovery systems for manned vehicles. Study is concerned only with spacecraft which develop lift as they re-enter. Both land and water recovery will be investigated.

Martin Considers 156-inch for Titan III

Martin Co. has investigated possible use of the 156-in. solid booster as a strap-on for the *Titan III-C* in place of the currently-planned 120-in. A study by Lockheed Propulsion Co. showed that only minimum structural modification would be needed.

INTERNATIONAL

ESRO Gets Telemetry Bids

Bids have been returned to European Space Research Organization for supply of telemetry and other equipment (M/R, Oct. 19, p. 24). Intended to fill a need for the next 15 months of sounding rocket work, the bids cover hardware for 70 payloads. Value of the overall hardware to be procured in this competition is above $1 million.

The Missile/Space Week

U.S., Germany Conclude Talks

Three modern guided missile destroyers, armed with the latest surface-to-air guided missiles, will be built by U.S. shipyards for the West German Navy, it was revealed in a detailed communique on the results of talks between Secretary of Defense Robert S. McNamara and his German counterpart, Kai-Uwe von Hassel.

Invitation for proposals to construct the destroyers will be issued about Dec. 1, with the contract awards by April 1, 1965. The first of the ships is scheduled for delivery in 1969.

As a result of the talks, the U.S. will continue to receive about $700 million annually in German procurement of American defense materiel and services. In addition to the destroyers, helicopters, missiles and ammunition buys are expected to maintain this level of spending.

On the Multi-Lateral Force, it was agreed that the "defense establishments" of both countries should be prepared "to implement the concept as soon as possible after the requisite international political decisions have been made."



Russian Missile Launched from Boat

MISSILE IS LAUNCHED from a Soviet rocket boat, apparently a PT-type vessel, during what the Soviet news agency Tass described as Red "army exercises." Tass gave no further details in releasing the photo. The boat appears to be the same as the Komar-class PT boats seen during the Cuban missile crisis of October, 1962. These missiles were described at that time as having a range of approximately 15 miles, and are believed to be designed primarily as anti-shipping weapons.

Shots of the Week

NASA concluded a six-vehicle series of sounding rocket shots from Wallops Station, Va., Nov. 12. The launches, all employing *Nike-Apache* rockets, took place in three pairs beginning Nov. 10. The first firing was at 5:25 p.m. (EST) Nov. 10 from the USNS Croatan anchored 75 mi. off Wallops Island. It was followed three minutes later by a second rocket launched from the island. Each reached an altitude of approximately 125 mi. On Nov. 11, rockets were fired, one from the ship at 5:24 p.m. and the other from the shore at 5:27 p.m. They reached some 200 mi. in altitude. The last pair was fired on the morning of the 12th, at 5:53 and 5:56, and reached 141 mi. altitude. All carried sodium vapor, which was released in clouds at altitude, for study in connection with the upcoming International Year of the Quiet Sun.

- NASA on Nov. 16 launched its first Project Luster payload from White Sands Missile Range, N.M., aboard an *Aerobee 150* vehicle. Payload recovery was being held up the middle of last week by bad weather in the mountainous area where it landed. On board was an ionospheric instrument under development by Electro-Optical Systems, Inc., for the Defense Atomic Support Agency (p. 24).
- The Air Force used a *Thor-Agena* booster to launch a secret satellite from Vandenburg AFB, Calif., Nov. 18.
- The Navy launched a *Polaris A-3* missile from the USS Pulaski Nov. 13 while it was submerged off the coast of Florida.

Minuteman Capability Hiked

An improvement program for the *Minuteman* weapon systems is underway at Boeing Co.'s Aerospace Div., now working on the R&D stage of *Minuteman II*.

E. H. Boullioun, Boeing vice president and branch manager, said he feels that the *Minuteman* system lends itself to further improvement that will result in significant advances in capability.

Although development of *Minuteman II*, with a more powerful second-stage engine and an improved guidance system, is on schedule, Boullioun said he believes a still better version could be developed within the next few years. It would probably be larger, carry a heavier payload and feature an even more advanced guidance system. Such a weapon, he is convinced, could be deployed in existing *Minuteman* silos with only minor changes in launching facilities.

Vela Results Revealed

Seismic propogation in the old sedimentary region of the Eastern U.S. is markedly better than that across the mountains of the West, Defense officials revealed in a preliminary analysis of the results of the underground nuclear test conducted near Hattiesburg, Miss., Oct. 22.

The 5-kiloton explosion—dubbed "Salmon" by Defense officials—was primarily to study the manner in which a tamped nuclear explosion generates shock waves in salt and to examine the way in which these waves propagate out of the salt dome and then travel in the crust and mantle of the earth.

Mariner IV Set for Nov. 27

The space agency has scheduled another attempt to launch the *Mariner* spacecraft on a Mars fly-by mission on Nov. 27.

The launch date was set following detailed analysis of the *Mariner III* flight, which failed on Nov. 5. Officials said study of the launch indicated the shroud covering the spacecraft did not completely jetti-

son as scheduled 5½ minutes after launch. As a result, the spacecraft could not deploy its solar panels and its batteries were drained nine hours after launch.

The investigation disclosed that the shroud, made of a lightweight glass fiber laminated honeycomb structure, probably had a structural failure when exposed to the flight environment. This prevented its separation from the spacecraft.

To solve the problem, NASA is turning to a magnesium shroud which is being built on a rush basis by the Lockheed Missiles and Space Co. One has already been completed and a second is being fabricated.

NASA Postpones Double Launch

NASA has postponed the launch of its first double payload—the *Air Density* and *Injun* satellites—until sometime this week at the earliest.

Flight was scheduled for Nov. 19 from Vandenberg AFB, Calif., on a *Scout* vehicle. It was scrubbed when a separation system, designed to part the satellites after orbit was achieved, was activated prematurely during the pre-launch checkout.

This immediately forced a five-day delay because tracking ships were permitted to leave their stations while NASA scientists attempted to find the source of the problem. The ships will not be back on station until Nov. 23. A definite launch date still has not been set.

Aerojet Stop-Starts Solid Motor

A small solid motor has successfully started and stopped more than six times in a company-sponsored program, Dr. Werner R. Kirchner, vice president of Aerojet-General and director of the company's Solid Rocket Operations told a Washington press conference.

A movable plug in the throat area of the nozzle was used to control the operation of the motor. Hydraulically-actuated, the plug is moved two inches in and out to vary the throat area. The resultant pressure drop when the plug is fully extended extinguishes the burning propellant.

In the test, Aerojet used a 4-in. motor with 6 lbs. of propellant. The motor was ignited, extinguished by the extension of the plug after 3-4 seconds of burning and then re-ignited after about 10 minutes. This cycling was repeated to give the starts and stops. The firing, which took place on Oct. 30, will be followed by five more motor tests over the next four months. At least one test will involve an 8 to 9-in. motor with a 100-lb. charge producing 2,500 lbs. of thrust.

GAO Probes Entertainment

The General Accounting Office has forced a number of firms in the industry to disclose names of government officials entertained at company expense, it was reported last week.

After obtaining the names, GAO investigators then questioned NASA and military officials involved on their relationships with the companies. Some of the visits, made within 48 hours of release of the names, were described as "FBI-like."

The aerospace firms were asked to reveal the names under threat of subpoena if they refused. The decision confronting management was whether to risk offending the government officials involved or to risk a court fight in which the company faced the innuendo that it had something to hide.

The GAO investigation was said to be on behalf of the investigating subcommittee of the House Armed Services Committee headed by Rep. Porter Hardy (D-Va.). (See editorial, p. 46).

SA-7 Film Found

Two camera capsules from the *Saturn I (SA-7)* have been recovered in the South Atlantic after seven weeks adrift in the ocean.

The 200 ft. of color film from the capsules, providing data on the rocket's operations in flight, was in good condition, NASA said.

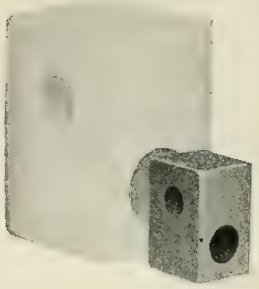
The capsules were found last week in the vicinity of San Salvador and Eleuthera Islands, about 140 miles apart. The recovery points were both more than 200 miles from the impact point. *SA-7* was launched from Cape Kennedy on Sept. 18 and impacted 530 mi. downrange.

Titan III-C Solid Fired

The *Titan III-C* 120-in. solid strap-on engine was fired, apparently with complete success, at United Technology Center's Coyote, Calif., development center.

The static firing was the seventh of the 120-in. solid conducted to date by UTC.

The engine burned for 110 secs., and preliminary data revealed "no anomoly at all." Brig. Gen. Joseph Bleymaier, Deputy Commander, Air Force Space Systems Div. for manned space systems, denied that the 120-in. program was lagging because of previous test failures.



THERE IS A NEW DIMENSION IN THE MEMORY MARKET

It is "MicroBIAX, a miniaturized version of the standard BIAX memory element—the tiny ferrite multiaperture core which stores data in Philco Corporation's remarkable family of BIAX memories and arrays.

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For more information write to:

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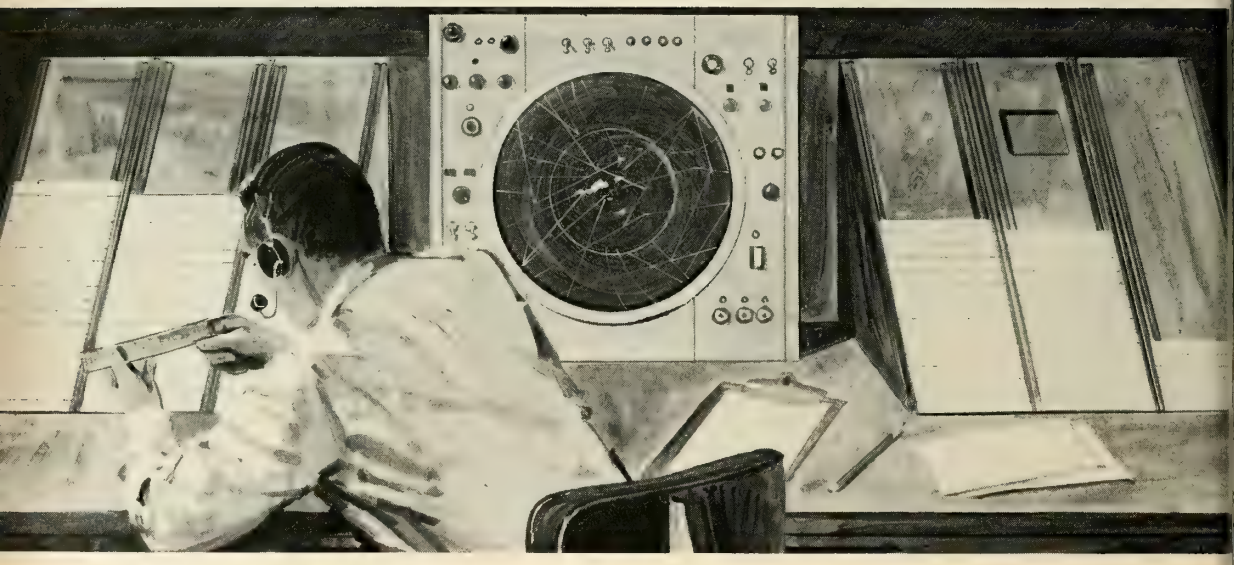
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FAA is upgrading area weather reporting



with a new Westinghouse picture transmitting system

Continuing its emphasis on greater air safety, the Federal Aviation Agency is conducting intensive R&D work to improve weather reporting. In an important step forward, Westinghouse is designing and building for FAA evaluation two prototype systems which will transmit ultra-clear weather pictures from remote radar sites to the air traffic control centers.

The new Westinghouse system compresses radar-detected weather signals from remote stations and transmits them to the control center over a conventional telephone line. In this manner a composite weather map of the region is instantly available to air traffic controllers.

Heart of the Westinghouse system is a vidicon type storage camera which is specially designed for slow scan or delayed readout applications. For the FAA system, readout will be on a two-minute frame basis, providing a brilliant, high-resolution image of slowly changing weather patterns on the air traffic controllers' displays.

The prototype systems, to be in operation at FAA sites on the East Coast by late 1964, represent a growing family of Westinghouse equipment for civilian aircraft and airport traffic control. These special-purpose systems are typical of Westinghouse capabilities in the design and manufacture of advanced electronic systems for defense and space. For information, write to Westinghouse Electric Corporation, P.O. Box 868, Pittsburgh, Pennsylvania 15230. J-02368

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Some details released . . .

Sprint Shape Shown At AUSA Meeting

Nike-X construction at Kwajalein disclosed; need for better surveillance systems noted

by James Trainor

EXTERNAL CONFIGURATION of the *Sprint* anti-missile missile was revealed to the public at the annual Association of the U.S. Army meeting in Washington.

The two-stage solid-propellant missile highlighted the Nov. 16-18 meeting which, in spite of the standards-of-conduct directive, set a new attendance record and saw an exceptionally fine turnout of industrial Army exhibitors.

Some 3,600 persons registered. The previous AUSA mark had been 3,100 registrants for last year's meeting. Over 150 industrial firms and 50 Army agencies participated.

Most noticeable effect of the ban on "hospitality suites" was an AUSA-sponsored hospitality lounge to which contractors could invite guests. However, this did not appear to be too successful and attendance was sparse.

● **Sprint details listed**—For the first time, the Army disclosed information on its high-acceleration *Sprint*. The missile is cone-shaped and is 4.5 ft. at the base. Its overall length is 27 ft. Guidance, as in all of the *Nike* family of air-to-surface missiles, is provided through ground commands to the missile. There are no fins on the aft end of the *Sprint*, indicating that no attempt is made to guide the missile during first-stage burn. The missile is popped out of its silo (see pictures, p. 18), the motor ignited and, at the same time, the missile is pitched over onto a trajectory toward its target.

Once the first stage has burned out and separated, terminal maneuvers can be made for final interception of the ICBM warhead. These maneuvers are probably quite limited and restricted to perhaps a final correction for intercept. No speed characteristics were released, except to say that the vehicle was hypersonic.

The Army did say that components of the *Sprint*—including both its motors—have been successfully tested. In addition, models of the missile have been emplaced in rocket exhausts to simulate the shock and high temperatures that *Sprint* will have to withstand in flight.

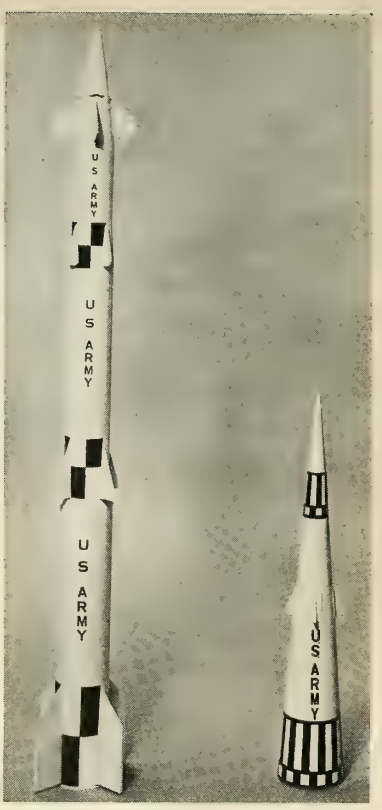
Also revealed was a construction program under way for *Nike-X* at Kwajalein Test Site in the Pacific. As reported in MISSILES AND ROCKETS last May, 55 acres are being added to the island for the construction of the multifunction array radar (MAR). Meck Island is also being pressed into service for missile launching cells and the *Nike-X* missile site radar. Total evaluation of construction and equipment on the test site is approaching $500 million, including ARPA's Project PRESS program.

● **Development efforts**—One of the greatest requirements for future Army systems is in the area of surveillance and acquisition equipment that will provide real-time intelligence and cover the entire area of influence, Maj. Gen. Frank T. Mildren, director of Doctrine and Systems Directorate in the Office of Assistant Chief of Staff for Force Development, told the convention.

Echoing that theme was Col. Allan G. Pixton, director of development in the Office of the Chief of Research and Development. Pixton told the attendees "Army R&D is developing greatly improved devices and techniques to enhance battlefield surveillance and target acquisition—utilizing such means as electronic photographic and various portions of the light spectrum. . . ."

"Ultimately, we hope to have a universal data link between the airborne unit and a ground target interpretation station, thereby precluding the need for the aircraft to return to base before its data is available. Such a system would provide rapid translation of the data into usable target information," Pixton said.

Other projects under consideration in-



COMPARISON of Nike-Zeus anti-missile missile and Sprint is illustrated above by two models. Three-stage Zeus is 48 ft. long, high-acceleration Sprint is 27 ft. Photo below shows full-scale model of Sprint shown for first time to AUSA.



clude *MARS—Multiple Artillery Rocket System*—which would be designed to deliver heavy accurate fire support by rockets using conventional warheads. Other sources told M/R that *MARS* is being looked at as a method of defeating vast armor attacks, the theory being that prior to an engagement, armor must mass as some location and this is the time it is most vulnerable. So far, *MARS* is nothing more than a study program.

In addition to some multi-barrel gun systems to complement *Hawk* for forward air defense, the Army is also investigating means of making the present *Hawk* more mobile and of adapting the air-to-air *Sidewinder* missile to a highly mobile, forward-area surface-to-air system.

Further details on the *Lance* surface-to-surface missile were also disclosed. The missile at launch weighs approximately 3,200 lbs., is about 20 ft. long and 22 in. in diameter. Mobility is achieved by a self-propelled launcher or a fully mobile, lightweight launcher as well as a transporter/loader. The missile can be air-lifted by helicopter or fixed-wing aircraft, or air-dropped by parachute. ■

In past year . . .

British Report Shows Big Increase In U.S. Strategic Missile Strength

U.S. STRATEGIC MISSILE strike forces increased dramatically over that of the Soviets during the past 12 months, the annual military review by the Institute of Strategic Studies indicates.

By mid-1965, the United States will have 925 operational ICBM's, plus 480 *Polaris* missiles, while the Soviets will have a total of 320 strategic missiles.

The Institute for Strategic Studies is a non-official private group in London that collects and analyzes data on the military strengths of all nations in the world. It is headed by former prime minister Clement Attlee and its prognostications are considered a relatively valid index of national military strengths.

The report gives support to Secretary of Defense Robert S. McNamara's contention that U.S. missile strength has increased both quantitatively and qualitatively over that of the Soviets. However, the report also notes that "this may be the last year in which the Western superiority in long-range striking power is so marked as the American ICBM program becomes substantially completed next year, and if the Soviet missile build-up is continued under Premier Kosygin and First Secretary Brezhnev."

● **Comparative figures**—A year ago the United States was estimated to have had 667 ICBM's as against 200 for the Soviets. This latter figure appears to have included submarine-launched missiles. The Institute estimates that Russia now has 200 ICBM's plus 120 missiles based in 40 submarines. Over 12 months then, the U.S. advantage has increased from a 3 to 1 superiority to 5 to 1.

This, however, does not tell the whole story. Qualitatively, the disparity is even greater. All of the Soviet ICBM's are liquid-fueled and are located in vulnerable sites. The report does not say anything about the second strike, hardened and dispersed ICBM's which the Soviets are now building. Nor does it take cognizance of the command and control problems that the Soviets have in trying to launch a coordinated mass attack against the U.S.

The one advantage that the report does list for the Soviet ICBM force is that because of the larger missiles, the warheads that can be carried are in the 30-megaton class. The largest U.S. warhead, on the *Titan II*, is estimated at 15 megatons. *Minuteman*, both *I* and *II* versions, carry approximately a 1-megaton warhead. This, however, does not take into account the increased effectiveness of the warhead with increased guidance accuracy. For example, halving circular error probability between *Minuteman I* and *Minuteman II* increases the effectiveness of the warhead by a factor of eight.

Another advantage of the U.S. force is that a majority of U.S. missiles are solid-fueled and, with improved command and control, can be launched singly or in a mass attack.

"There is no sign of any significant reduction in the number of the 750 Soviet IRBM's targeted on Western Europe and Japan, or in its force of 1,400 medium bombers."

Turning to the submarine fleet of the Soviet Union, the Institute points out that the Soviets still maintain a numerical superiority of about 400 submarines. It estimates that in addition the Soviets have 30 nuclear submarines. This figure includes both attack and ballistic missile subs. For the first time, the Institute estimates that some of the ballistic missiles can be fired from a submerged submarine.

Again, however, the qualitative advantage of the U.S. *Polaris* force is apparent. Soviet sub-launched missiles have a range of less than 400 mi., whereas the *Polaris A-3* has a range of 2,850 statute miles. This also supports Secretary McNamara's contention that the Soviets are far weaker than the U.S. in this category. His estimate of Soviet sub-launched missile ranges was less than one-third that of *Polaris*.

● **Production rates**—The report estimates that the Soviets are building and deploying ICBM's at a rate of 100 per year. This is less than one-third the rate at which the U.S. is emplacing *Minuteman*.

Production rate of Soviet nuclear submarines is estimated at 10 per year. Of this, six submarines are ballistic-missile firing boats and four are attack submarines. The report notes "there are indications that the Soviet naval air force and missile-firing submarines are coming to play a more central role in her strategy."

The reason that the Institute feels that U.S. numerical superiority may diminish is that by 1967, the U.S. ICBM and *Polaris* forces will be essentially complete while, if the Soviets continue their rate of production beyond that, the numerical disparity will diminish.

● **China: paper tiger**—In spite of the surprise over the advanced design of the triggering mechanism for its first nuclear device and the use of uranium 235 rather than plutonium, the Institute feels that the Chinese Communists will not be able to develop a strategic strike force in the foreseeable future. Rather, the Institute feels that the Chinese are concentrating on tactical nuclear weapons—particularly battlefield missiles.

The Chinese could produce a thermonuclear device of "boxcar dimensions" in two or three years. Such a device would be comparable to the first U.S. thermonuclear explosion in the Pacific in 1954. ■

For six-month operation . . .

Power Is Problem in Voyager Lander

Avco expert tells AIAA meeting other troubles are sterilization and lack of Martian data; details of dual-purpose spacecraft operation

DEFINITE ADVANCES in the state of the art will be required in the *Voyager* planetary lander if it is to operate for six months with the use of a radioisotope power supply.

This was emphasized by Dr. Paul C. Dow, Jr., of the Avco Research and Advanced Development Div., in an address to the New York section of the American Institute of Aeronautics and Astronautics.

Two other problems—spacecraft sterilization and the lack of information regarding the atmosphere and surface topography of Mars—are also complicating design of the 7,000-lb. *Voyager* spacecraft. However, these are not felt to be as severe as the power supply problem.

Avco, General Electric and Lockheed have been the major industrial contractors studying the *Advanced Mariner/Voyager* planetary programs.

Describing the two missions, Dow said that in both cases, "the approach which we have followed will make use of a dual-purpose spacecraft. The spacecraft will act as a bus to carry a lander which will be separated from the bus as it approaches the planet." The bus, depending on which mission is being flown, would continue to fly by or would go into orbit around the planet.

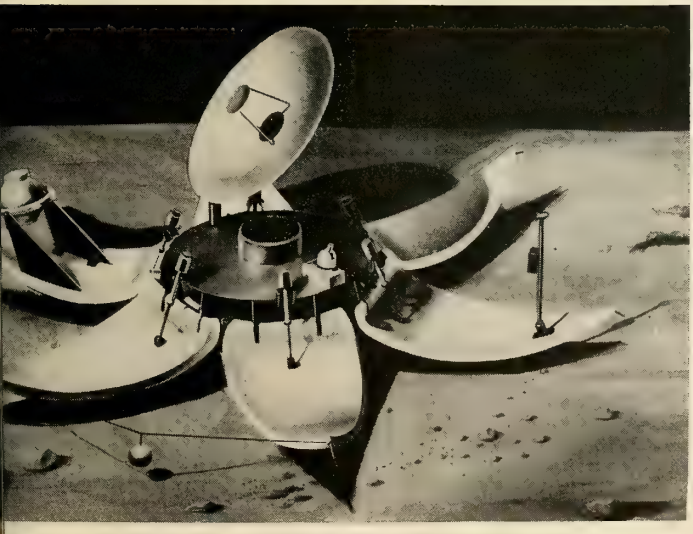
● **Landing routine**—The lander for *Voyager* will be separated from the spacecraft and spun up by spin rockets; its own propulsion system will then be fired to place it on an impact trajectory. When the lander decelerates to a fairly low velocity, a drogue chute will be deployed to pull away the heat shield and release the landing payload.

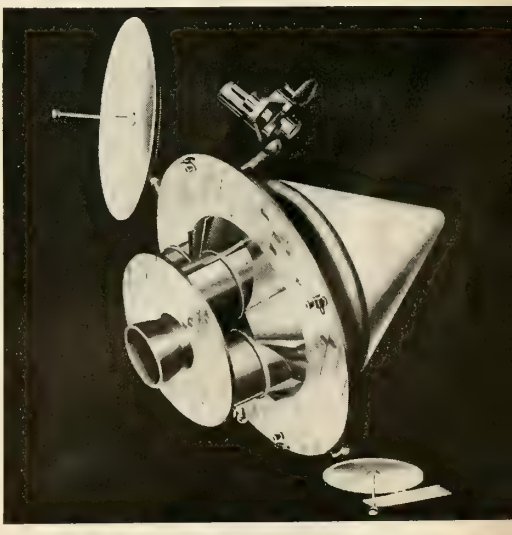
Acorn-shaped, the lander will be designed to assume a more or less upright attitude after impact. When the sides of the lander are deployed, they will force it into an erect position. After that, 5-ft. parabolic antenna will be erected to transmit data directly back to Earth. A second VHF self-leveling antenna will also be provided so that data can be transmitted from the lander to the orbiter and then to Earth as a back-up link.

Primary missions of the lander are: first, to perform exobiological investigation; second, to make geophysical and geological measurements; and third, to obtain information for a manned landing.

To put the spacecraft bus into orbit the main propulsion system will be ignited and burned for about 15 minutes. Once in orbit, a large, 8-ft.-dia. antenna will be deployed to allow a greater data-transmission capacity to Earth. A helical antenna will also be used to communicate with the lander. Primary payload for the orbiter will be television cameras and other scientific instruments to measure such things as magnetic fields and infrared radiation from the planet.

● **'69 advantageous**—Setting various limitations on the landing site selection, such as requirement to land on the Sunlit side of the planet and the need for a steep entry angle to insure that the lander is captured by the atmosphere, Dow said that the 1969 launch opportunity is particularly conducive to the collection of scientific information. Whether NASA will conduct any mission in 1969 or whether it will have to wait until 1971 still has not been decided. NASA has recommended such a mission to the Budget Bureau, but as yet does not know if the recommendation will be approved. ■





VOYAGER SPACECRAFT in-transit to Mars would have fixed orientation so that solar cells, covering about 200 sq. ft., would constantly point at Sun. Lander, after landing, would peel apart, righting instrument package and stabilizing it. Launched by Saturn IB/Centaur, 7,000-lb. spacecraft would have own propulsion for mid-course correction.

As atmosphere diluent . . .

Soviets See Helium Use in Spaceships

Prediction that Russians 'undoubtedly' will adopt lighter gas in future surprises U.S. experts at Bioastronautics Symposium

by Heather M. David

SAN ANTONIO, TEX.—Soviet scientists are very interested in using helium as a diluent gas for spacecraft atmosphere instead of the nitrogen which has been used in all Soviet space shots to date.

Dr. O. Gazenko, one of the USSR's top space physiologists, told MISSILES AND ROCKETS that helium will be used at some time, because of the thermal and decompression protection advantages it offers over nitrogen. He said the subject is a matter of scientific controversy in the USSR, but that "undoubtedly" there will be a shift to helium at some time in the future.

He denied that this meant that the Soviets have had any trouble with the present environmental control system, which he described as an oxygen-nitrogen mixture with temperature range from 11-30°C, and humidity from 35-69%. Oxygen content ranged from 19-29%, with a carbon dioxide rate of from 0.2 to 0.7%. He indicated that the environmental control system was tuned for individual preferences among the cosmonauts, measured by skin condition.

U.S. scientists are also beginning to look at helium for its future potential, for much the same reasons. The Garrett Corp., for instance, has demonstrated that a higher cabin temperature can be withstood because of the thermal transfer properties of the gas. In addition, because it is less soluble in blood than nitrogen, it is not expected to cause the bubbling problem, or "bends," encountered in moving to a lower-pressure environment—as from cabin to suit operation.

The Air Force coincidentally began a 15-day helium-oxygen atmosphere confinement experiment at Brooks AFB Nov. 16, in which four men are breathing a 46% oxygen, 54% helium mixture at one-half atmosphere.

However, U.S. space medicine experts voiced surprise at the definiteness with which Gazenko stated that the helium system would be used. While it is being investigated as a possibility by the Air Force, it is not being seriously considered for any planned missions, Dr. B. E. Welch said.

Welch, whose section at the School of Aerospace Medicine has conducted most of the atmospheric tests for the Air Force and NASA, said that helium still has some big question marks, such as whether the very insolubility of the gas in body fluids might be more hazardous in a rapid decompression, where it would tend to be lost more quickly. Voice communication, once thought a problem, may not be at reduced pressure, he said.

● **Spacesuits**—The Soviet scientists, who included Gazenko, Dr. V. V. Antipov, and Dr. M. M. Kosenkov, were attending the Third International Symposium on Bioastronautics and the Exploration of Space, held by the Air Force Aerospace Medical Division here last week.

According to Gazenko, who reported on physiological aspects of *Vostok* and *Voskhod* flights, the cosmonauts at no time wore pressure suits during the recent three-man *Voskhod* spaceflight. While it has been assumed that the cosmonauts donned pressure suits during boost and re-entry, as is planned for the otherwise shirt-sleeve *Apollo* mission, he said that not even this protection was used. He reiterated their extreme confidence in their sealed cabin protection.

He said that the absence of spacesuits made it possible to perform a number of experiments using sensors directly on the skin even during these periods.

Panel Favors Orbiting Small Animals for 3-12 Mos.

AN AIR FORCE PANEL studying plans for the *Manned Orbiting Laboratory (MOL)* has concluded that there is a need for a small-animal *Biosatellite* that would be put into orbit for three to twelve months to evaluate effects that may occur at the cellular level.

The group, composed of Air Force scientists and civilian consultants, reported at the Third International Symposium on Bioastronautics and the Exploration of Space that it will recommend that small animals such as mice or rats would be more useful than larger animals.

They said they reached this conclusion because of the lower sustenance requirements of the small creatures, their less difficult waste management, and the advantages afforded by their rapid development. The quicker physical growth of the smaller animals in effect increases by a factor of five to ten the value, for study purposes, of their time span in orbit.

The panel's report is now being readied for presentation to official levels.

The Air Force previously has met with some lack of success in getting approval for its animal program. An example is the *Discoverer* monkey program, for which it eventually dropped its plans.

The new program would contrast with the *Biosatellite* program of NASA, which will last 30 days. The panel indicated it felt that the NASA program would provide adequate information for that period of time.

Among the sensors used, he said, were measurements of the electrocardiogram, respiration rate, electroencephalogram, eye movements and seismocardiogram.

● **Visual experiments**—The cosmonauts, like U.S. astronauts, saw objects on the ground which they could identify, according to Kosenkov. He listed mountains, rivers, shoreline and towns, but did not give the exact measurement of the smallest object viewed.

Kosenkov said Soviet spaceflights have demonstrated that the spectral sensitivity of the eyes when in orbit is close to ground values. He added that no anomalous phenomena were observed, and that all the cosmonauts have seen the colors on test cards which were given to them when they were in orbit. Visual acuity did not decrease by any more than 10% after insertion into orbit, he said.

Kosenkov disclosed that the Russians are interested in the possibility of using cabin indicators—such as electronic signals—in an economical way which would utilize one signal display for a number of different purposes. A shuttering technique would be used so that the indicator would relate only to information necessary for a given portion of the flight. This, Kosenkov said, frees the pilot from seeing a lot of useless information when he does not need it.

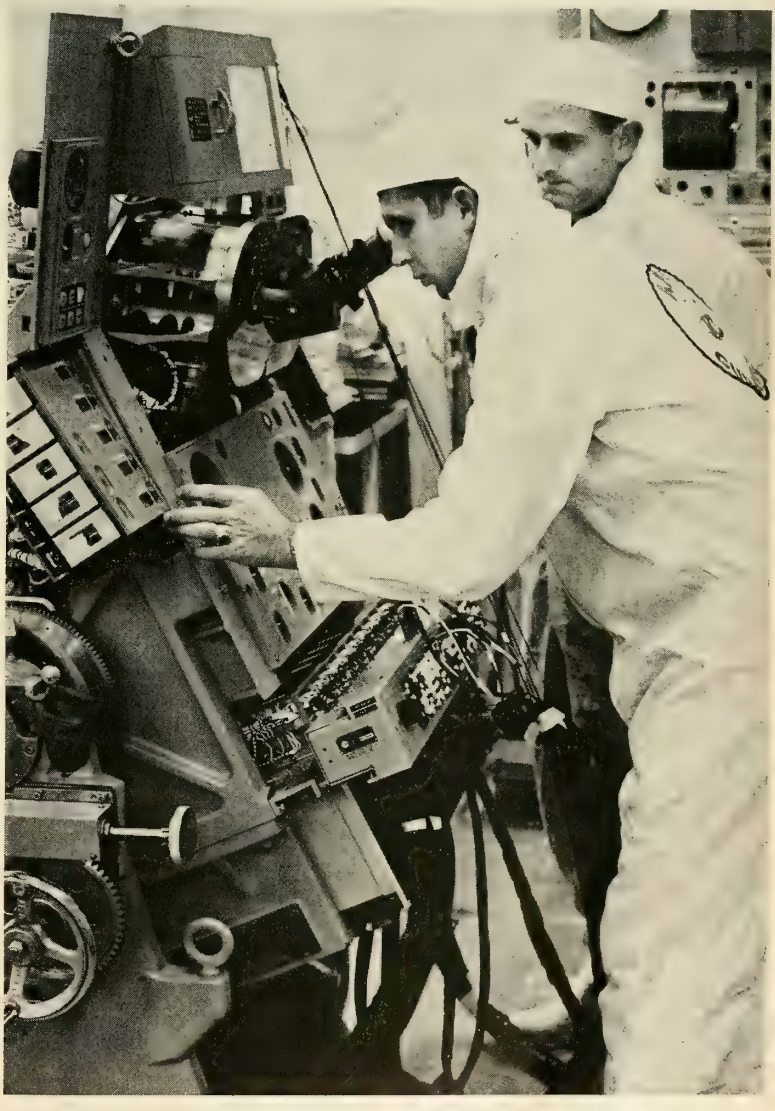
He also said that present Russian efforts are going to problems of stereoscopic vision, optical illusions and deep-space myopia, to determine the parameters of optical equipment which should be furnished.

● **New biological data**—Antipov, a radiobiologist who has authored a number of papers at international meetings in the past, said that *Voskhod* preliminary results indicated a "substantial contribution" to knowledge about the effects of spaceflight factors upon biological organisms.

Among the most significant changes which have been revealed in tissue experiments, he said, are those which show that new, spherical fragments occur in cells in all stages of division. These changes, he said, have only been duplicated in Soviet research under extremely high g forces, such as 4,000 g. They have thus far been tied to the boost and descent phase of the flight, with the greatest number of changes occurring during the first hours of flight, and the least just before re-entry.

Antipov also disclosed that in one *Voskhod* experiment, a number of cells were flown which have been flown on previous spaceflights, specifically *Vostoks 4* and *6*. He said this indicated that the tissues can maintain viability with repeated exposures, and possibly that some selection takes place. By studying the ones which "selected themselves" he said, a great advantage will be gained in calculating what happens to human cells.

● **Vestibular difficulty**—The second indication of some vestibular disruption in Soviet spaceflight experience was indicated by Gazenko, who said that Popovich felt sensations similar to those appearing during Coriolis acceleration. He said, however, that these diminished and then disappeared when the cosmonauts strained against their couches. Gherman Titov's earlier, more severe experiences of nausea are now generally considered to be an individual peculiarity. ■



Apollo Command Module Guidance Tested

FIRST PHOTO OF APOLLO Command Module integrated guidance system, developed by AC Spark Plug, and the Kollsman optics to be used for star fixes to check navigation. Shown under test are the telescope, inertial measurement unit, and the digital guidance computer, developed by Raytheon Company.

Buoyed by firing successes . . .

Nuclear Rocket Backers Bid for Post-Apollo Role

Finger says outlay of $1 billion would produce rocket ready for operation in 1975; LASL turning to Phoebus

PROPONENTS of the nuclear rocket are making a firm bid for use of their engine concept in the national space program after *Apollo*.

The nuclear propulsion program, meanwhile, for Fiscal Year 1966 probably will get the same funding as in the current fiscal year—$150 million—according to NASA and AEC officials.

Looking ahead, an AEC-NASA official claims a total of about a billion dollars more would be needed to bring the nuclear rocket into the flight-test stage by the early 1970's, and operational by 1975. Speaking at a recent Washington conference, Harold B. Finger, Manager of the joint AEC-NASA Space Nuclear Propulsion Office, also also said he would like to see a RIFT-type program reinstated; but he did not expect this to happen in the next Fiscal Year.

RIFT, a Reactor In-Flight Test program, was cancelled last year for economic and technical reasons.

The programs "ideally" suited for the nuclear rocket are said to range from missions involving manned exploration of Mars to ones calling for logistics vehicles for flights between Earth and the Moon.

● **A tremendous advance**—So pleased are AEC and NASA with the recent highly successfully series of hot firings of nuclear reactors, particularly after a notable failure earlier in the year, that Finger claimed they certainly indicate a "step improvement" in rocket systems.

Pressing the point further, he enthusiastically added that "these tests constitute the largest advance in rocketry and in rocket performance that has been made since Goddard started flying his pump liquid-rocket systems in the '20's.

The tests referred to were of the Kiwi and *NERVA* reactors. Kiwi is the name given to research reactors developed by AEC's Los Alamos Scientific Laboratory (LASL). The technology developed in this program, and the basic designs, have been used to build the *NERVA* reactor and experiments. The work on *NERVA*, which stands for Nuclear Engine for Rocket Vehicle Application, is performed by Aerojet-General Corp. and Westinghouse Electric Corp., reactor subcontractor to Aerojet.

On Aug. 28, there was a test of the Kiwi-B4E reactor, eighth and final reactor to be fabricated under the Kiwi program. This was presumably the world's first successful "hot" test of a nuclear reactor developed for propulsion purposes.

The reactor ran at planned power and temperature for more than eight minutes, the maximum time possible with the available liquid hydrogen supply. This run was followed on Sept. 10 by an unprecedented "restart" test.

Then, on Sept. 24, the first power test of the *NERVA* Experimental Reactor, the NRX-A2, was conducted. The reactor performed at the planned power and temperature without incident. This reactor also was restarted and run at low power for 20 minutes on Oct. 15.

Finger made the point that these tests have demonstrated that "we can build these reactors for nuclear rockets and have them operate successfully (and) we can achieve, actually achieve, the performance that we . . . predicted."

Specifically, the test data verified that a specific impulse of 750 seconds or higher could be achieved, when corrected for altitude and jet nozzle area ratio. This compares with 300 to 450 seconds for the chemical rockets now in use or under development.

The thrust achieved during the tests ranged between maximums of 50,000 to 56,000 lbs. These thrusts were downplayed as not being the fundamental parameter; the reactors can be made bigger in order to get higher thrusts. "Specific impulse tends to be a more fundamental parameter and our work is aimed at going even above 750 seconds," said Finger.

An important point about the tests that received only passing attention was that the reactors were started automatically, from no-power to full power, the way a normal control system would operate them. This is not the usual way reactors are started; they are commonly nursed through lower power levels up to the higher ones.

● **The next step**—Now that the reactors have shown they can operate at least for short periods of time, the advanced program is to refine the design in order to provide operations for extremely long periods. Also, there will be attempts to push the specific impulse higher by elevating the operating temperature and power density of the reactors.

Part of next year's *NERVA* program is to breadboard the pump, reactor and nozzle into a self-contained system and see how they interact with the control system. There are no known analytical means to predict this function.

This work will be followed by down-firing engine tests, as opposed to the up-firing tests that have been run.

Although the Kiwi development program does not include such an experiment, the Los Alamos Scientific Laboratory is planning early next year to run the Kiwi TNT test—transient nuclear test. This is a safety test aimed at learning what happens if there are rapid transients in power. They will be obtained by rapidly rotating the control drums around the reactor core.

With just about all of its Kiwi work done, LASL has turned most of its attention to *Phoebus I*, an advanced reactor of Kiwi-size that will serve as the stepping stone to *Phoebus II*, sometimes known as the *Advanced Phoebus*, of 250,000 lbs. thrust. For an advanced Mars mission, it is proposed that two or three *Phoebus II's* be clustered in a stage for departure from Earth orbit; another *Phoebus II* be used in the second stage of the spacecraft for deceleration into the Mars orbit; and a *Phoebus II*, or possibly a *NERVA I* for Mars orbit departure. *NERVA I* is based on the Kiwi reactor; *NERVA II* on the *Phoebus II*.

For lunar work, a *NERVA I* engine used as the third stage on a *Saturn V* would be able to carry a 47,000-lb. payload directly from Earth to the lunar surface, according to Finger. This would be enough payload to give four astronauts a 30-day dwell period on the Moon. An all-chemical rocket could not carry enough payload for a direct lunar flight and return. If launched on an advanced *Saturn V*, the nuclear rocket stage could give dwell times of 90 days or more. ■

NASA Moves to Develop Ramjet

Proposals to be received in six weeks for research vehicle design; flight-test should begin in 1968; program will involve X-15

by Hal Taylor

PROPOSALS LEADING toward the development of a hypersonic ramjet research engine have been requested by NASA for delivery by Jan. 7, 1965.

Three firms will be selected for Phase I of the project, which calls for conceptual and preliminary design of a flight engine. During Phase I work, the firms will prepare engine development plans. These plans will serve as technical proposals for Phase II, during which the engine will be built.

Phase I will last nine months. Development will be initiated on Phase II late next year. Plans now call for flight-test of the engine in early 1968, with a two-year flight-test program envisioned.

The space agency said that until recently the design and construction of such a research engine would have been virtually impossible because of important gaps in essential knowledge. Now, the agency continued, component research appears to have narrowed the gap sufficiently to make construction of a research engine feasible.

● **Ramjet dividends**—The ramjet engine is considered a promising propulsion system for flight missions at hypersonic speeds because of its relative fuel economy. It probably would attain speeds above 3,300 mph, or more than five times the speed of sound.

The ramjet powerplant is expected to be useful for hypersonic aircraft, boosters and spacecraft flying within the atmosphere. It is believed that it will provide marked advantages over other flight powerplant systems because of its reduced weight and improved flight efficiency.

In its simplest form, the ramjet has no moving parts. In contrast with the turbojet engine, which requires a mechanical air compressor, the ramjet compresses air by ramming it into the front of the engine at high speeds.

Energy is added by burning fuel in the compressed air. The combustion gases then expand rearward through the engine's tailpipe to produce thrust. The ramjet operates best at speeds of 2,000 mph or more, in the speed range above turbojet engines.

● **X-15 involved**—The hypersonic ramjet experiment project is intended ultimately to include flight research with the engine mounted on the *X-15 No. 2* airplane. Guidelines for preliminary design include a weight limitation of 800 lbs. for the final research engine, including necessary flight-test instrumentation. Dimensions are to be compatible with mounting the engine near the lower aft fuselage of the *X-15*.

The *X-15 No. 2* will be capable of carrying 110 gals. of the liquid hydrogen fuel specified for the engine.

The NASA bid request seeks a ramjet capable of operating at flight speeds between Mach 3 (about 2,000 mph) and Mach 8 (about 5,300 mph).

The hypersonic ramjet project is in the programs of the Aeronautical Research Division of NASA's Office of Advanced Research & Technology. ■

NASA Continuing Manned Flight Priority

NASA APPARENTLY will not support the National Academy of Sciences recommendation that the next U.S. space goal following Project *Apollo* should be unmanned exploration of Mars during the 1971-85 period.

The agency, informed sources report, is going ahead with the preparation of its Fiscal Year 1966 budget —which, while containing funding for unmanned exploration of Mars, will continue to place the bulk of funding in manned spaceflight programs. This will include the first hardware money for *Apollo X* or *Apollo* Extension Systems.

While most officials of NASA's Office of Space Sciences and Applications agree with the Academy's view, the state of affairs for unmanned programs is illustrated by the current fate of the 1969 *Voyager* mission.

Although top NASA management would like to fly the mission, the restrictions imposed by the Budget Bureau apparently will not leave enough money in the FY '66 budget to do it. NASA could probably scrape enough money up by slowing down or cutting some manned spaceflight efforts, but top officials have thus far ruled out such a course.

● **Board's report**—The Space Sciences Board of the National Academy of Sciences expressed its position on the primary future U.S. space goal at the request of NASA Administrator James E. Webb.

The report was received by the agency on Oct. 30, and made public by the Academy last week.

The Academy said the alternatives to unmanned exploration—extended lunar exploration and manned space stations—are not regarded as primary goals because they have less scientific significance.

"The manned Earth orbital program should be a secondary, not primary, goal," the Academy told NASA. "This would include the development of rescue service for unmanned vehicles and several military objectives, such as inspection."

The Board said that in the view of many scientists the outstanding problem of our times is whether or not living forms have developed on Mars. For this and many other reasons, it called on NASA to use *Saturn*-class vehicles, including the *Saturn V*, to launch unmanned flybys, orbiters and landers to the planet.

The Academy also recommended that NASA continue its Earth satellite and application programs at the current level and consider probes reaching into the solar corona, out of the plane of the ecliptic, to a distance of 40-60 Astronomical Units from the Sun, and to Mercury and Jupiter.

First Photos of Sprint Dummy 'Pop-up'



PHOTO SEQUENCE released by DOD last week shows pop-up test of dummy of Army's Sprint anti-missile missile at site near Orlando. TOP LEFT: Test cell before ignition of charge under dummy. TOP RIGHT: Dummy clears cell, positioning wedges fly away. BOTTOM LEFT: Tethers check dummy at top of flight. BOTTOM RIGHT: Dummy suspended on cables.

Technical Countdown

ELECTRONICS

Radiation/Thermal Chamber Designed

A planetary radiation simulator has been designed by Philco Corp.'s WDL Division to meet the need for adequate environmental testing of spacecraft, the firm reported at the AIAA Space Simulation Testing Conference at Pasadena, Calif. Walter G. Camack said that although there is a need to simulate albedo and planet radiation as well as solar radiation to test spacecraft thermal design, planet sensors and guidance and navigation systems, such simulators have not been devised. Philco has found that the required strongly directional emitting sources can be provided with cone optics.

Autopilot Testing Crucial for Spacecraft

Spacecraft autopilot testing will be increasingly important as the complexity of spacecraft propulsion systems and structural properties increases. Jet Propulsion Laboratory told the AIAA Space Simulation Testing Conference. Noting that payload capabilities of the *Saturn* launch vehicles portend a large jump in size and complexity of future spacecraft, John F. South said future space simulation facilities should be designed for this class of spacecraft rather than the intermediate class suitable to the *Atlas-Centaur* boosters.

STS Passes Acceptance Tests

The Special Test System (STS), under development by General Precision Inc.'s Kearfott Division to test an advanced stellar inertial guidance system, has successfully completed acceptance tests. A part of the STAFF Program for the Air Force's Ballistic Systems Division, STS is designed to test the stellar IG unit in a ballistic missile boost phase and in the space environment. First flight tests of the system will be made in a *Polaris A-1* from Eastern Test Range.

MATERIALS

Thiokol Testing New Additives, Oxidizers

Beryllium additives and high-energy oxidizers are now being developed in Thiokol Chemical Corp.'s new high-energy solid-propellant plant at Brigham City, Utah. The plant will manufacture several other new propellants recently developed in Thiokol labs. Wasatch Division is testing solid fuels using beryllium additives for possible use in the NASA *Surveyor* program, and research is being conducted on high-energy oxidizers including hydrazinium diperchlorate. Plant facilities include a vertical propellant mixer with 1,000-lb. per hour capacity, a 25-ft.-deep casting pit, process control lab, static-test firing area and X-ray pad.

PROPULSION

260-in. Firings To Be Increased

The static test program for NASA's 260-in. solid-rocket-motor development appears to have been considerably expanded. Now in Phase I development by Thiokol and Aerojet-General, the big motor is expected to undergo full-length test firings under Phase II during 1967-69. Each firm will fire two half-length motors during Phase I. Only two full-length motors were to have been fired by the competition winner, but NASA now indicates that from 6 to 8 will be tested. Incremental funding of about $20 million for the motor tests is expected to appear in the Fiscal Year 1966 budget request.

Ozone Stabilizer Discovered

Researchers at the Department of Chemistry, Massachusetts Institute of Technology, happened across a method of storing ozone that may lead to its use as a rocket fuel. While studying ways to utilize sunlight, Prof. L. J. Heidt and a pre-doctoral student, V. R. Landi, found that the breakdown rate of ozone can be reduced and smoothed out by increasing its alkaline environment. The chemists kept ozone on a 50% solution of sodium hydroxide for some 83 hours with an ozone loss of 50%. The researchers suggest that ozone might be stored and transported safely in containers whose inner walls were lined with an alkaline material. Both researchers noted that the work involved relatively small amounts of ozone and bulk properties might differ. In addition, the chemical damping action of alkaline compounds on the violently reactive ozone is not known.

SPACE MEDICINE

Brain Plugs Developed

A "plug-in" electroencephalograph that can be used with animals for spaceflight experiments has been developed by Amphenol-Borg Electronics Corp. The connectors and leads are surgically placed while the animal is under anesthetic. After this one operation, a number of different instruments can be attached to the plugs which project from the animal's cranium. This would allow researchers to selectively stimulate or monitor different brain areas.

Vibrations Beneficial to Astronauts

Vibration as a means of counteracting the debilitating effects of weightlessness is proposed by J. E. Beaupeurt of the Boeing Co. after a number of tests using vertical, sinusoidal vibrations at Boeing's Wichita vibration facility. While it was found that subjects vary considerably in their tolerance, some vibrations were found tolerable and even pleasant enough to warrant proposing them for reduction of physical fatigue, increasing alertness and stimulating circulation. Beaupeurt said it is quite likely also that vibration could be used to alleviate weightlessness effects on the musculo-skeletal system.

In-Flight Training Method Perfected

Feasibility of using a small on-board training device during extended spaceflight was studied at NASA's Langley Research Center with the conclusion that such a system is useful for maintaining skills and could be developed with small weight and volume requirements. Method uses electronically generated disturbance signals summed with manual control inputs to the attitude stabilization system. The disturbance signals create perturbations on the spacecraft, which the pilot must control.

AF Pushes Work on IC Exploitation

Three new demonstration hardware programs under way at Wright-Patterson; phased-array work started at TI

by Michael Getler

DAYTON, OHIO—Three new Air Force projects aimed at application of advanced microelectronics to operating experimental hardware packages are now under way in the Electronic Technology Div. of the Air Force Avionics Laboratory at Wright-Patterson AFB here.

One project has already been funded, RFP's on the second system are already out, and those for the third effort are expected to be issued within the next few months. The three programs include:

—A terrain-following phased-array airborne radar system which could have major long-range application to advanced missile fire-control radars.

—A microelectronic version of an individual adaptive element which could then be arrayed in large numbers to form future pattern recognition or adaptive control systems with many possible applications.

—A very-high-speed video processor which would allow the Air Force to move ahead with advanced digital communications systems.

All three programs involve very heavy use of integrated circuitry, reflecting the continuing AF drive, led primarily by the Avionics Lab, to fully explore use of these devices in virtually every electronic systems category of future importance to the service.

The likelihood that the Air Force would support new developments in these areas as well as in several others, and the intention of the service to continue using actual demonstration hardware projects, or so-called "research vehicles," as the best method to expand the technology, were reported in MISSILES AND ROCKETS, Aug. 31, p. 14.

● **Phased-array radar**—The phased-array radar program began late in September with an award to Texas Instruments, Inc.'s Apparatus Div. in Dallas after preliminary studies had been made in-house by the Air Force. The initial award to TI is worth about $500,000, but there is a strong possibility that funding may grow considerably in the future and perhaps include other contractors.

Though the research vehicle being developed by TI is aimed primarily at low-level navigation radar, the implications of the technology are extremely broad, representing an exploration of many new and novel techniques for utilizing integrated circuit and microwave devices in various radar applications. AF engineers here stress that they will support work beyond that now under contract to attempt to ferret out all possible applications.

AF engineers feel that the current effort should culminate in a highly advanced, first-of-its-kind, operating radar in about 3-4 years.

Present planning calls for TI to produce a monopulse-type, microelectronic, phased-array radar that will operate at X-band and incorporate many integrated-circuit subsystems not now in existence, operating in conjunction with solid-state microwave power components used as radiating elements.

The radar is expected to include many new analog-integrated circuits, function generators in integrated form, higher-frequency integrated IF strips, and new integrated power amplifiers.

The array itself will be composed of some 500 individual semiconductor radiating elements, each putting out peak power of 1 watt. Each element will be part of a roughly 1-sq.-in. plug-in, replaceable module that will contain a power amplifier, varactor multiplier, IF pre-amplifier, and T/R switch. Switching equipment for the array beam will be mounted behind the modules. With this type of array and use of pulse compression techniques at the receiver, engineers here estimate the system will yield performance equivalent to a more conventional short-pulse radar with an effective peak power somewhere in the vicinity of 20-50 kw.

Another bonus, the Air Force says, is that conventional stabilization equipment, which normally stabilizes an airborne radar dish during flight maneuvers, will not be needed, because of the controllable array beam pattern. Engineers further believe that techniques used for digital switching of discrete lengths of transmission line to get the necessary phase shift for the radar may also be applicable to other ground-based array radars.

By going to a multi-element phased-array that allows use of many lower-power solid-state output devices, engineers here hope to achieve reliability improvements on the order of 9 to 1 over existing conventionally configured non-solid-state terrain-following radars, as well as 2-to-1 reductions in size and weight figures.

To expand phased-array terrain-following radar techniques into missile fire-control and air-intercept problems requires considerably more power, which might impose restrictions on the use of solid-state power components, but the Air Force feels that with more development this, too, may be possible.

The Avionics Lab is expected to investigate this area, and is also likely to study the use of integrated circuits in some of the related fire-control subsystems (other than the computer area where they are now in use) such as in active filtering systems used for information extraction from target signals. TI, in its radar development, will also explore the use of integrated solid-state design in the power regulator subsystem.

● **Adaptive element**—RFP's have been issued by the Electronic Technology Div. for development of a small, microelectronic version of an adaptive magnetic-type element which, if it can be evolved, will serve as the basis for later procurement of a new research ve-

hicle in the area of a pattern recognition or adaptive control system. Contractor selection for the initial effort is expected in about four weeks.

These elements, which have been built using conventional electronic design, basically provide variable linear gain with permanent memory. If they could be reduced in size by several orders of magnitude, their use in arrays of perhaps 2,000 elements might lead to deployment, for example, in target identification roles associated with data-processing subsystems, in several possible control system applications, in weather forecasting, and in speech recognition.

● **Digital communications**—The Division's interest in advanced digital communications systems currently is centered on achieving a capability to handle video channels in real-time through development of the key new subsystem that is required—a very-high-speed video processor. The ability to process video rapidly with a microelectronic system could, for example, give the Air Force a strong future capability for on-board processing of reconnaissance data.

In order to develop such a processor, both higher-speed logic and higher-speed data sampling rates will be needed. Engineers here say the latter requirement probably is more difficult to cope with.

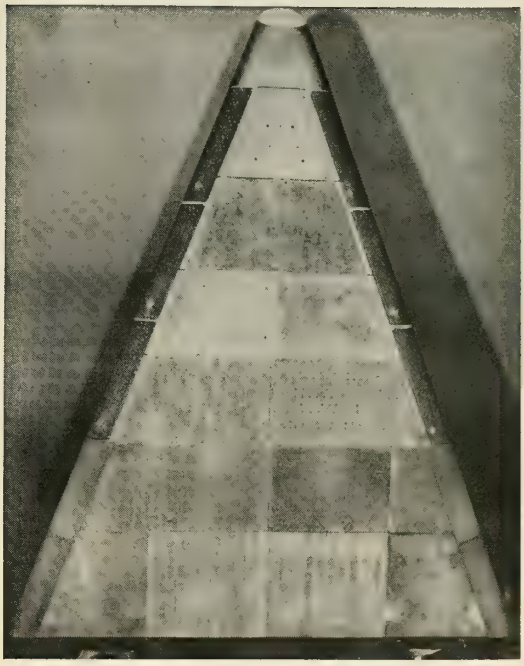
Basically, AF engineers are interested in being able to interrogate a 6-mc-bandwidth video channel, for example, at about a 12-mc sampling rate, which would allow working systems to run at clock rates on the order of 100 mc with associated high resolution and accuracy.

In order to push the sampling rates, a/d conversion rates, and clock rates to new ground, the Division will pursue development of new 100-mc logic with nanosecond delay times, new data-compression systems using integrated circuitry which might conserve bandwidth requirements, and use of passive thin-film circuit depositions on top of larger-area active silicon circuit arrays for gains in the sampling and logic portions. The Division has worked on this latter development for about three years, with some of the effort performed under contract to Motorola.

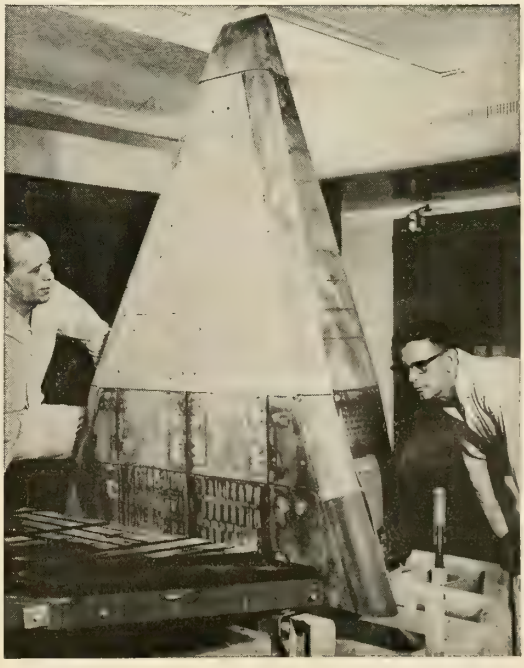
The Air Force says it would like to have such an advanced system operating in about two years, and that it is likely to take the first step—development of the processor—through issuance of RFP's in the next few months. A full-scale communications systems task probably would be initiated in about a year.

In connection with such a system, engineers here say they will also look at advanced designs for phase-lock receivers. They claim that these appear "to be a natural" for redesign with integrated circuits. ■

Coating Protects ASSET



RECENTLY RELEASED photos of first ASSET vehicle to be recovered for study following its glide re-entry show how it was preserved in re-usable condition by special diffusion alloy coating developed by Chromalloy Corp., of West Nyack, N.Y. Top photo shows lower glide surface of the McDonnell Aircraft-built ASSET, with its variety of "chromallized" molybdenum panels, before flight. Photo below shows same ASV-3 vehicle after completed flight and re-entry on July 22. Even after prolonged heating to almost 3,000°F, bottom glide panels are in "like-new" condition. Unscathed vehicle structure could be flown again, if desired.



Modular Payload Developed for Probe

Package being built for Army by Electro-Optical Systems offers advantages for radiation measurement, other ionospheric work

by William Beller

A MODULAR PAYLOAD package now under development for the Defense Atomic Support Agency (DASA) may play a significant role in probing the ionosphere for radiation data if the U.S. resumes atmospheric testing of nuclear weapons.

The modular approach is advantageous not only because of its low cost for a repeated series of tests but also because it makes it possible to replace obsolete instrument modules without redesigning the payload package.

Other advantages include flexibility —being able to substitute one experiment or series of experiments almost minutes before a flight—and the assurance that back-up modules can be within reach if a malfunctioning module shows up.

● **Stacked like chips**—The present payload system, designed and built by Electro-Optical Systems, Inc., integrates the electronics for seven measurement and support functions into separate cylindrical modules of the same diameter. These standardized units can be quickly and interchangeably stacked and fastened to actually form the rocket's forward section.

In the past, payloads for scientific ionosphere probes have usually been custom-built for their special role in each particular mission. Still, as far back as the *V-2* rocket, in its scientific use in the U.S., some attempts were made to standardize instrumentation and even introduce modular units. Because of the relatively primitive nature of the upper-atmosphere sensors at that time, however, they did not lend themselves to the more sophisticated approach.

As a result, scientific devices for rocket installation were usually extremely difficult to service or replace once installed in the launch vehicle. The situation has not changed significantly over the years.

The new, integrated EOS system will presumably provide upper-atmosphere researchers with easily installable and quickly interchangeable instrument and support modules. The equipment was developed under contract to the Army Ballistic Research Laboratories, Aberdeen Proving Ground, Md., acting for DASA.

The second structural flight test is planned for January at Eglin AFB, Fla. Lofted by a *Nike-Javelin III*, the 120-lb. package is expected to reach 150 km. On the first flight of the payload earlier this fall, the ogive broke up.

If all goes well with the January test, the payload itself will be installed for a flight test in March, John Mester, project manager for the project and ABRL's chief of applied physics, told MISSILES AND ROCKETS.

● **Easy access**—Each of the seven modules built under the $221,000 Army contract is open at both ends for electronics installation and servicing, said Dean E. McDowell, EOS supervisor for the project. He explained that these modules—comprising one payload—contain measurement components attached either directly to their inside cylindrical walls or to interior wall subframes.

Payload measurement devices include an electron-ion temperature experiment, propagation beacons, a radiation detector and a Langmuir probe.

To further strengthen the multipurpose payload concept, all support modules for the system have been predesigned to meet a variety of different probe requirements. EOS cites the power supply system as an example: it has 100% more current capacity than is presently required and could be interchangeably used in systems demanding more current. It provides regulated outputs of ±12 volts and ±28 volts.

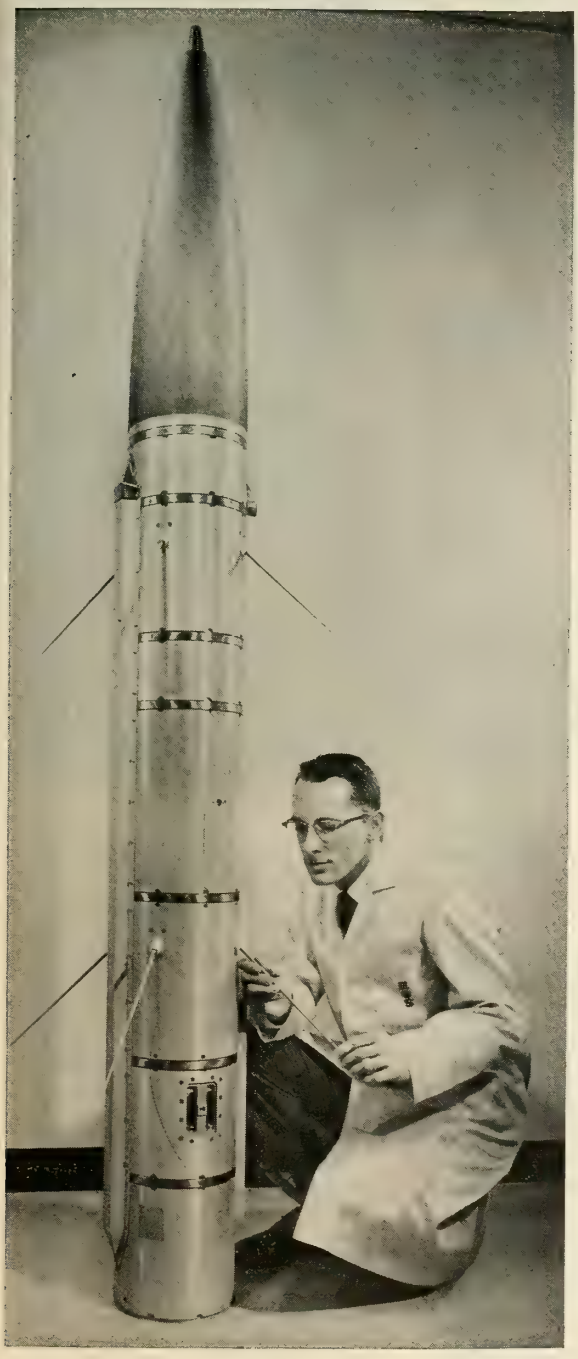
In addition, the designers say, the telemetry package has more data-handling capacity than is presently necessary, in order to accommodate simultaneous signals from a broad range of instruments.

EOS is presently working on a combined ranging, tracking and telemetry system with even broader capabilities for future integrated payloads. The company believes that once standardized packaging techniques are applied to additional support units and instruments—electron density and solar flare experiments, for instance—the costs involved in upper-atmosphere research will be significantly reduced.

In launch configuration, the EOS cylindrical modules will be stacked and fastened one on the other with Marman-type ring clamps using a single bolt each. The cylinders have a length of from five to ten inches and an outside diameter of nine inches.

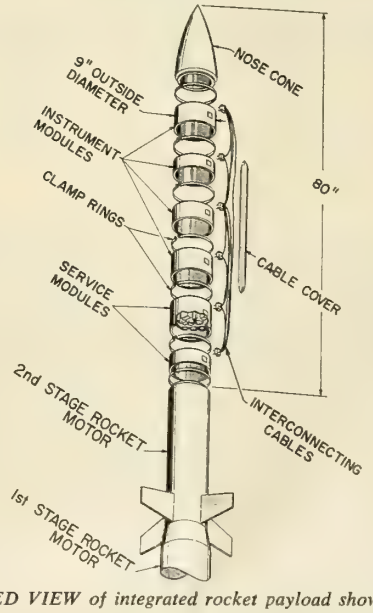
Removal of any module in the payload will be accomplished by first detaching metal cable covers extending the length of the nose section and then unbolting the two ring clamps holding that particular module. Since the length of the payload is determined solely by the number of modules required for a specific probe, only the external cables and cable covers need alteration for each new mission.

BELOW: Interchangeable modules (from top): nose cone with beacon antennas inside, Langmuir probe, propagation beacon, magnetometers, ion trap, telemetry and power system.





INTEGRATED PAYLOAD aboard launch vehicle. Cable covers and antennas are only external attachments in nose section.



EXPLODED VIEW of integrated rocket payload shows separate support and instrument cylinders.

The EOS design couples the missile nose cone to the uppermost instrument module. Distance from motor bulkhead to the tip of the nose cone is approximately 100 in.

EOS for many years has developed specialized probe instrumentation, including satellite and rocket photometers, beta and gamma ray detectors, solid-state electron telescopes and gamma-ray telescopes.

The company is currently constructing an ionospheric instrument which will open beam-like arms in flight to intercept and capture lunar dust or ejecta falling toward Earth. Development of the unit, whose initial flight was made last Monday on an *Aerobee 150* vehicle sent into the Leonid meteor shower, is funded through a NASA contract under Experiment Luster. ■

GD/A Rotational Test Results Are Encouraging

Five-day, 6-rpm centrifuge run produces no ill effects on engineer subjects

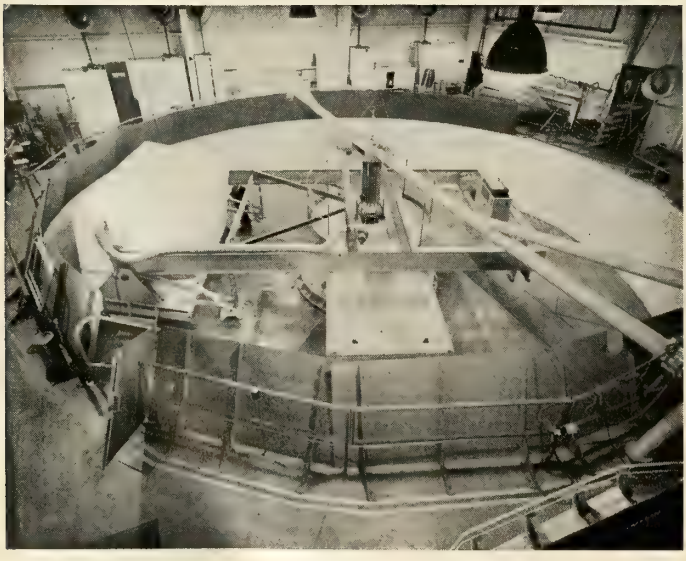
A FIVE-DAY rotational test at General Dynamics/Astronautics designed to see if the theoretical endurance limits of human beings can be raised has had such good results that post-flight testing was cut by a day and a half for lack of adverse symptoms.

According to Dr. Bernard Newsom, chief of Aerospace Medicine at GD/A, the results were so encouraging that they will help to remove the traditional constraint on engineering design that humans can tolerate circular motion to the extent of only 4 rpm at a 40-ft. radius. The test subjected four men to 6 rpm for five days at a 20-ft. radius, and as Newsom says, "it's obvious that we are not reaching the optimum tolerance at six revolutions per minute."

During the five days, two men adapted to the rotational rate within 24 hours, the other two within 48. During the acclimatization period, the crew felt "stomach awareness," but not the extreme nausea or vomiting that has been reported in other tests.

Although it will take a week or so to get the fine analyses of psychological and biochemical tests performed during the run, Newsom said that in all appearances, there were no changes, no difficulties in performing tasks, and no disorientation.

The men performed the kinds of tasks that would demonstrate whether they had the kind of motor ability necessary for space station operation. These included movements such as pointing, button pushing, looking from side to side, depth perception, memory and reasoning tests, and walking from one place to another.



CENTRIFUGE at General Dynamics/Astronautics used in five-day test.

● **Equipment**—The simulation was conducted on the Manned Revolving Space Systems Simulator (MRSSS) at San Diego on company funds. It is part of a program, Newsom said, to define all the real constraints imposed both by providing gravity and operating in zero-g before a decision is made or whether space stations must be rotated or not. This test was aimed at determining needs of interplanetary flight or year-long space station work, rather than *Manned Orbiting Laboratory* or *Manned Orbiting Research Laboratory*, he said.

Eventually, he said, GD/A would like to see what kinds of perturbations associated with space stations complicate the problem and how they affect the optimum tolerance. This would lead to calculations of what work man could do at what rotations, with what kinds of perturbations. The company also is conducting an equally large study on how man can adapt by exercises to operate in a zero-g space station.

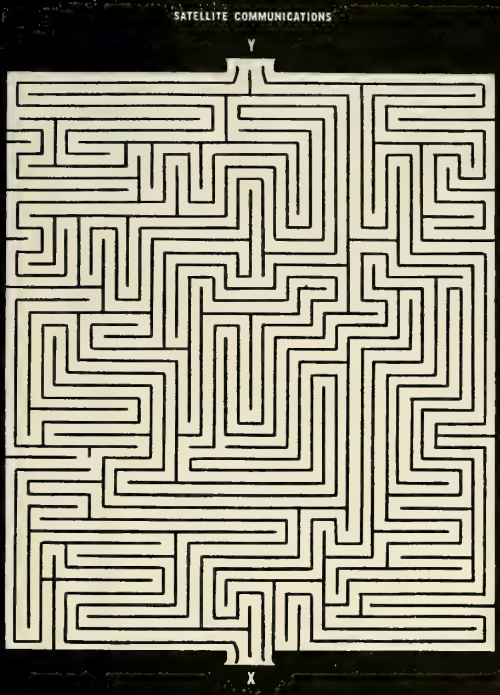
The MRSSS chamber in which the test was conducted is a room 14 ft. long x 7 ft. wide and 8 ft. high mounted across the arm of a centrifuge with a 20-ft. radius. Trunions allow the chamber to swing out or tilt as the rotational speed increases.

This tilting, so that the resultant of the centrifugal and gravitational forces is perpendicular to the floor, may be the reason why the subjects did not experience the ill effects encountered in other tests.

Newsom said that the fact that the rotation was gradually increased by 2-rpm steps also might account for the success. The men entered the chamber Nov. 4, for 24 hours acclimatization, then spun up Nov. 5 to 2 rpm for four hours, and then to 4 rpm for four hours. Velocity was then stepped up to 6 rpm for 104 hours.

The spin-down was accomplished in the same cycle on Nov. 10. The four men, who are research engineers at General Dynamics, were expected to remain in the chamber for 48 hours for post spin testing. However, 12 hours testing was deemed sufficient since there were absolutely no symptoms.

● **Environment**—The men breathed normal air supplied through an air conditioning system. Medical monitoring included electrocardiogram, blood pressure, respiration, temperature, etc. The men also acted in a buddy system to perform psychological and physiological tests to see if they could perform this space station function also. ■



Approaches by the score—
Find the right one!

Working with the Air Force to find the right one from among the many approaches to military satellite communications is one of the vital national-defense missions of Aerospace Corporation. Specifically:

We plan: Aerospace helps determine the nature of our military satellite-communications program. Should it be a high-, medium-, or low-altitude system? How can we be sure of having a satellite where and when we need it? Resolving such basic questions as these, Aerospace structures an over-all plan for Air Force approval: for example, the recommendation might be a medium-altitude, multiple-satellite system that would provide optimum coverage.

We guide: Aerospace provides systems engineering on an approved system, resulting in specifications and plans for development of the satellite-communications system. Typically, the Corporation brings contractors face to face both with problems and suggested solutions. Aerospace also provides technical direction during the development, manufacturing, and launch phases and participates in the co-ordination of the ground stations, launch vehicles, and payloads.

We probe: Analysis of industry's antenna design approaches, coding circuits, etc., followed possibly by experimentation and testing for sensitivity and environment, is also part of Aerospace's mission.

The future is anticipated by studies such as the application of millimeter-wavelength communications to the problem of transmission through plasma sheaths. For these studies, Aerospace uses a unique antenna, accurate to 20 seconds of arc, to operate up to 240 Gc.

We need: Senior engineers and scientists challenged by the complexities of advanced thinking will find a stimulating atmosphere at Aerospace Corporation. For information on current career opportunities, write Mr. Stephen Robinson, Room 105, Box 95085, Los Angeles 45, Calif. An equal-opportunity employer.

The problem is one of getting from X to Y without entering a blind alley at any time. Look well ahead! (From *Mazes and Labyrinths, a Book of Puzzles*, by Walter Shepherd; Dover Publications, Inc., New York 14, N.Y.)

AEROSPACE CORPORATION

Organized in the public interest and dedicated to providing objective leadership in the advancement and application of space science and technology for the United States Government.

Northrop Gets in LSV Battle With Company-Funded Development

Proposal, now vying with NASA-supported studies at Boeing and Bendix, features eight wheels and walking-beam suspension

by Russell Hawkes

NORTHROP Space Laboratories has entered the competition for a lunar surface vehicle (LSV) that will serve as a mobile laboratory (MOLAB) after the U.S. has made its first manned exploration of the Moon.

The firm has committed company funds to developing the LSV, thus bucking NASA-funded studies being conducted by The Boeing Co. and Bendix Corp.

The proposed LSV is an eight-wheeled chassis carring a cylindrical pressurized lab module for two astronauts, plus the necessary on-board systems and expendables. The lab and chassis are connected by a three-point mount to minimize heat leakage to the ground and also to limit the twisting stresses transmitted from the chassis to the pressure cabin as it moves over rough terrain.

The Northrop design philosophy emphasizes that the vehicle is primarily a mobile laboratory rather than a transportation system. But a modular design approach has been used to enable NASA to replace the pressure cabin with some other payload so that the chassis can be used as an unmanned transporter for a variety of purposes. Aside from the chassis, all other LSV systems are derived from those used in the *Apollo* Command and Lunar Excursion modules to minimize new engineering.

● **Novel suspension system**—The most distinctive feature of the LSV is its walking-beam suspension. Northrop engineers claim that tests with one-sixth-scale models indicate it should have outstanding performance over the standard obstacles specified in Annex "G" of NASA's MOLAB request for proposals.

The eight-wheeled system has many of the advantages of an endless tank track over rough ground, along with somewhat greater locomotion efficiency. Like the tracked systems, it uses "scuff steering" whereby differential power is applied to the wheels on opposite sides and it can turn about its own center of gravity.

On the basis of present information, Northrop favors wheels. But if new data revise current estimates of lunar surface characteristics, the walking-beam suspension can easily be adapted to tracks.

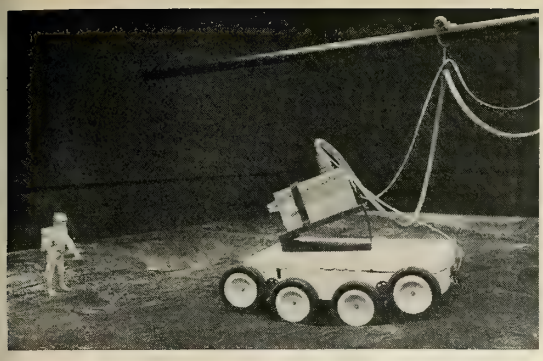
Northrop has verified in scale-model tests that flexible wheels like those proposed by a number of aerospace companies are superior to rigid wheels for bad surfaces, but are less efficient on good surfaces. Engineers are now experimenting with variable-rigidity wheels that can be matched to any surface.

● **Steering system**—The vehicle has four wheels on a side. Each wheel is powered by an independent, series-wound d-c motor. The front two are mounted on one beam and the aft two on another. Each beam is attached to the glass chassis by a center pivot. The astronaut-driver may let each beam rotate freely on its pivot or he can use power controls to drive it to a selected angle and lock it there. It amounts to a variable-configuration suspension that can be adapted to the terrain ahead.

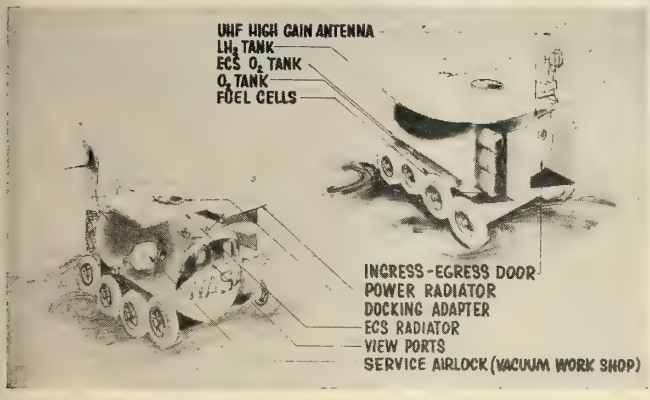
By driving the beams to a vertical position, the LSV can be given ground clearance equivalent to that of a vehicle with much larger wheels. Its relatively small wheels permit lower drive and braking torque requirements. With all eight wheels on the ground, its center of gravity is lower than that of a large-wheeled vehicle, offering better stability on rough ground.

To traverse the side of a steep slope, the driver could use the walking beams on the down-hill side as jacks to level the floor and keep the overturning moment within limits. Northrop engineers think it may be possible to lock the wheels and rotate the walking-beam continuously to "crawl" through deep dust or sand. For most conditions, the suspension will be operated with the beam rotating freely on its pivot.

Of the vehicle's 7,000-lb. gross weight, Northrop charges only 823 lbs. to the locomotion system, excluding its share of the hydrogen and oxygen used by the three *Apollo* fuel cells that supply current to the wheel motors and walk-







TOP LEFT: TV camera on remote-controlled one-sixth-scale model of Northrop's Lunar Surface Vehicle is being used to evaluate astronaut visibility from MOLAB in simulated Earthshine and sunlight on a model of lunar surface derived from Ranger VII photos. Model uses eight-wheeled Northrop "walking beam" locomotion system. TOP RIGHT: Northrop scientists Walter Kuehnegger (in spacesuit) and Dr. Howard Heglin simulate mission in full-scale mockup. LEFT: Artist's drawings show division of cabin into two compartments—control station forward and airlock compartment in rear. Driving or vehicle control station is forward and to left of cabin, putting driver on vehicle centerline. Mission control station is forward and to the right, next to driver.

ing-beam motors. The rotating pressure seals for the motors are regarded as critical development problems. The automatic speed and torque-sensing controls for the independent wheel motors are not expected to give any difficulty.

• **Getting it there**—NASA has specified that MOLAB is to be lowered to the surface of the Moon unmanned by a LEM descent stage between three months and six months before the arrival of its crew. During this period, it is to function at a low power level conducting limited experiments and collecting operational data to prepare for the arrival of the manned LEM, which will be the base of the mobile operations.

At the end of this "dormant" phase, it is to be occupied by astronauts for 14 days of extensive exploration.

The Northrop LSV is designed to the payload limitations of *Saturn V*. The descent stage will fit comfortably within the LEM adapter. If weight-lifting capability is increased, it will be possible to increase the length of the lab module without altering the adapter.

The LSV has a maximum surface range of 400 mi. Since the LEM may land at some distance from the mobile lab, a substantial part of this range may be used to drive the lab to its crew by remote control.

A television system and a comprehensive guidance and navigation system aboard the lab provide steering information to the controller—who may be one of the astronauts in the LEM, the one orbiting the Moon in the Command Module or an Earth-based controller in the *Apollo* ground operations support system.

The lab module on the LSV is mounted on the right side of the chassis and the three fuel cells and their tankage are on the left side. This arrangement simplifies plumbing, and weighs less than if the pressure cabin was centered and the other components mounted on either side.

With the driver sitting on the left side of the cabin, he is located on the center line of the chassis. If manned descents are to be made in the LSV, the docking adapter must also be located on the left side of the cabin directly over the center of gravity so that the docking impact will not send the vehicle tumbling.

• **Interior configuration**—Northrop has designed the lab with two compartments, the smaller of which serves as an airlock for departing and returning astronauts. The small compartment has extra radiation shielding so that it can be used as a "storm celler" during solar flares.

Wherever possible, the subsystems of the study vehicle have been located to provide some shielding against radiation and micrometeorite bombardment. Thermal radiators almost completely cover the top and left side.

A useful feature of the Northrop LSV is a small airlock through which lunar samples can be passed for study within the lab. When vented to the outside, it can serve as a "vacuum workshop" in the same way vacuum chambers do in Earth-bound labs. A remote manipulator enables astronaut selenologists to collect specimens without leaving the lab. The vehicle's weight summary allows 600 lbs. for scientific equipment.

• **Lunar light considerations**—Northrop is using LSV models on a representation of the lunar surface to determine what trouble the driver will have guiding himself by visual reference to objects and surfaces outside the lab. Floodlights and optical collimators simulate illumination by the Sun and the Earth's albedo.

Preliminary results indicate that even in the latter case, lighting will be very harsh and objects in the shadow will be invisible. For operations in the intense light of the Sun, window filters will be needed and the high reflectivity of these is likely to require dimmed interior lighting when the lab is being driven. The Northrop lighting studies will also establish design parameters for the TV systems.

Project officials at Northrop Space Labs estimate that they could deliver an LSV prototype within four years of go-ahead. If, as some observers expect, NASA elevates the MOLAB to full project status in early 1966, a Northrop LSV could be available for the second or third LEM descent to the Moon's surface in 1970 or 1971. ■

Eurospace Outlines Plans For Joint Aerospace Transporter

Report recommends two-year, $6-million study to press 'unique' opportunity; $100-million is total cost estimate

by Frank G. McGuire

GENEVA—Eurospace has issued its detailed report on the proposal for an all-European aerospace transporter and recommends further feasibility studies before any significant financial outlay is made.

The intra-European industrial organization, with some U.S. associate members, has proposed that governments concerned allot about $6 million for a two-year feasibility study to determine the detailed nature of the project.

"The magnitude and cost of such a project is such that only one solution can be finally considered, and this must be shown to be more fully technically justifiable than is possible in the present report," the document said.

"It is recommended, therefore, that under the sponsorship of the European governments concerned, perhaps, for example, within the framework of the European Launcher Development Organization, a consortium of those interested companies should be established. This group would exist outside the jurisdiction of Eurospace, although that organization would remain at its disposal."

Europe is now on notice by its own top-notch missile/space planners that time is growing short and that ". . . similar work is in progress in the U.S. and undoubtedly in the USSR and that any further delay will jeopardize this unique opportunity for Europe to enter the space field with its own firmly based technical policy."

These are the key elements in the 58-page document intended as a follow-up to last year's published proposals for an aerospace transporter utilizing horizontal takeoff techniques for placing large payloads into space with recoverable vehicles.

● **Cost figures**—Being devoid of projects of such magnitude, the planners were hard put to come up with firm cost figures. However, based on U.S. *X-15* experience, Eurospace feels a figure of $100 million is reasonable over the length of the program, but is planning to take a harder look at this figure during the feasibility studies recommended.

Even the $6-million feasibility study figure is merely an estimate. "The precise figure involved would arise from the contractual negotiations."

In the report, Eurospace tried to allay the fears of a large and possibly fruitless expenditure for the studies by pointing out that, when divided among the participating countries, the figure is small.

● **Time scale**—Taking into consideration the various vague and undetermined aspects of the aerospace transporter, the industrial group feels a time scale of 10 to 15 years is realistic. Barring use of a single-stage configuration using either nuclear or air-scooping techniques, the report feels a staged LOX/hydrogen system is best, with simultaneous development of air-breathing systems recommended.

Assuming this configuration, the time scale of 10-15 years is given.

In the development program involving all rocket engines, work on the horizontal catapult launcher and rocket engines would begin immediately after completion of the feasibility studies, with the rocket engine work taking at least six years. Powered flight would begin about four years after completion of the studies, with orbital flights beginning two years later. Final development phase would be rendezvous in orbit, commencing about eight years after completion of feasibility studies.

In the development program involving an air-breathing first stage with horizontal takeoff, two alternatives are presented in the report: a Mach 4.5 engine and a Mach 7 engine for the first stage. No catapult is included in the program, and engine development begins immediately after study completion, with this phase expected to last about 7 to 9 years depending on the engine velocity.

First stage flight tests would begin about four years after initiation of active development, while rocket engines for upper stages would begin development about three years after study completion. Flight testing to orbit is expected about eight years after studies are completed for the Mach 4.5 engine and 10 years for the faster version.

● **Missions**—Trying to avoid duplication of U.S. and Soviet work on expendable rocket boosters, European efforts have been aimed at original thinking in areas where no definite conclusions have been reached by either of the two space giants. Consequently, a manned Earth-to-orbit-and-return vehicle for personnel transfer has been selected as a first project.

The official description of the aerospace transporter's general reason for being is straightforward: "The aerospace transporter is essentially a type of Earth surface-to-orbit vehicle designed to carry reasonably physically fit personnel (e.g., engineers, construction crews, scientists) without subjecting them to excessive strain and fatigue that would impair their efficient operation." No vehicle configurations are postulated.

Logistics is the greatest single justification for the vehicle, says Eurospace, and even though it is conceivable that the major powers will make use of it, the development must be considered in a purely European context. Aside from logistics for serving space stations (or establishing them), the transporter is seen as useful for servicing and inspecting missions to satellites whose reliability has faltered.

Other missions include the acquisition of scientific data on such phenomena as solar eclipses, weather, upper atmospheric and ionospheric character-

istics to supplement data gathered by unmanned satellites.

A subsidiary consideration in the report is use of the transporter for hypersonic transport between two points on the Earth's surface without an orbital flight.

● **The joker**—"As has been stated previously this concept as a civil design is considered to rely on the existence of a European space program to supply the necessary load requirements for its justification. It is hoped, however, that a program for this period (1975-80) will soon be the subject of a special study."

With this statement, the report revealed the joker in the deck.

Although not providing specific figures for an estimated load requirement to service Europe's needs, the report uses an order-of-magnitude approach based on an American source. Eurospace notes:

"According to this reference, it can be expected that five years after the commencement of space operations the annual tonnage required would be of the order of 100 tons, while after 10 years it would be 1,000 tons; that is, an order of magnitude improvement after five years. These figures are, however, very provisional and are no substitute for a proper assessment of European requirements."

The industrial report's tone is one of: "Here's what we can do, government; now how much backing can we get?" Obviously, political considerations, commitments to strictly national efforts, budget worries, and similar nontechnical considerations will weigh more heavily than anything calculable on a slide rule. How well European governments are prepared to back up their desires with action will be seen in coming months.

● **Design features**—The transporter is being contemplated on a basis of a presumed ability of placing 1.5 tons of transferable cargo/personnel in orbit. This figure excludes about one ton of fuel equivalent to a characteristic velocity requirement of about 2,000 fps, assuming a mass in orbit of about seven tons and a specific impulse of 430 seconds.

In the chemical rocket configuration, use of present fuel combinations, design approaches and launch methods, would result in a vehicle the size of a *Saturn* 1C and an extensive launching complex, says the report. It cites a figure of 10% mass ratio for the stages. For these reasons, as well as financial considerations, the approach was dropped.

Other booster approaches for the chemical rocket phase include an advanced two-stage LOX/hydrogen winged vehicle, each stage of which would be manned and recoverable. Assuming equal characteristic velocity increments and a structure ratio of 20%, this design would enter orbit with a mass of about 7% of its takeoff mass, a figure that includes the second stage deadweight.

Use of a catapult, the Eurospace report says, would increase this mass ratio to about 8%, if the catapult could impart 1,000 ft/sec to the vehicle at takeoff.

● **Booster recovery**—In a choice between passive recovery via parachute or paraglider, or active recovery via a piloted booster recovered at an airfield, Eurospace has leaned 90% in the direction of the latter. This is one of the questions to be answered by the recommended feasibility study, but the only unanswered question seems to be the cost of developing a manned recoverable booster versus the less-desirable but cheaper parachuted variety.

Without question, the hope is to launch and recover the vehicle within Europe rather than have a long trek to either Australia or another remote site.

● **Booster alternatives**—Although citing a single-stage system (nuclear, for example) as the ideal, no serious expectation is voiced that these will appear in the time period under consideration. Instead, development of an air-breathing propulsion system for first stage operation is urged, with second stage separation occurring at about Mach 7. Fuel would be kerosene, and takeoff would be vertical, inclined or horizontal, with the last method most likely.

A number of research laboratories are carrying out work in the field of high-Mach-number engines for atmospheric operation, and an answer concerning optimum speeds, designs, and efficiencies within the next decade will aid the final choice. As presently outlined, the transporter would have its air-breathing engine topped by two rocket stages burning LOX/hydrogen.

Present state-of-the-art would permit design and use of an engine operating at Mach 4.5 to 5, the report says, but for greater speeds more data would be needed on intake and nozzle aerodynamics, combustion under the anticipated conditions, and materials.

Possibilty of developing a turborocket with second stage separation at Mach 4.5 has also been considered, again with all stages burning LOX/hydrogen except the first stage, a kerosene unit. Mass in orbit with this design would be about 5.5% of the launch mass, compared with the 7.5% figure for the Mach 7 air-breathing engine.

The Mach 7 engine figures assume a first stage structure mass ratio of 30% and a mass ratio of 15% for the stages.

● **Manned aspects**—Maintenance of a satisfactory environment, integration of man into the vehicle system, and provision of safety and survival equipment are all spelled out as areas requiring specific attention in the feasibility studies recommended in the report.

On the subject of cabin atmosphere, 100% oxygen appears the initial choice for short missions, and a mixed gas for longer missions, although these also are subject to later confirmation.

On his role in the system, man is considered by the Eurospace report to be either a payload for servicing orbiting satellites manually, or as an integral part of the vehicle system. Considerable human engineering is expected to be required on all aspects of this man-machine integration question.

● **Re-entry and landing**—Maximum equilibrium surface temperatures foreseen as a design objective are about 2,000°C in the stagnation region and about 1,400°C on the average. The effects of banking, says the report, are such that at a 45-degree bank (corresponding to maximum lateral range) the heating would increase about 20%. For a glide re-entry at small angles with an L/D of about two, the maximum input rate would be somewhere around 35 Btu/sq.ft./sec with a total heat input of about 80,000 Btu/sq.ft.

Various assumptions used in obtaining these figures are subject to later confirmation and elaboration through research and development.

Deceleration upon re-entry is expected to be limited to about 1.5 g, based on the anticipated length/diameter relationship.

Landing footprint has not, of course, been determined yet, but with an L/D ratio expected to be in the neighborhood of 2.0 to 2.5, this would yield a lateral range up to 2,500 miles, with longitudinal range dependent largely upon re-entry velocities.

● **Configuration**—Basic outlines of the re-entry vehicle are given by the Eurospace report as follows:

"The re-entry vehicle configuration would probably have a flat undersurface design suitable for radiation cooling, operating at high angles of attack and well suited to low landing speed requirements. The wing would be of low aspect ratio with thick blunt surfaces to meet landing conditions, operating at low speeds with a large area of separated flow. The requirements for leading edge and nose are conflicting, varying from fairly sharp to improve hypersonic (L/D) max, radiused from the heating viewpoint and rounded to meet subsonic requirements.

"Wing loadings of the order of 30-50 lbs./sq.ft. or less should be possible with an L/D max. of 2.0-2.5. Control problems associated with maintaining effectiveness over the speed and altitude range of flight might call for some variable geometry." ■

NAA Building 'Largest' Centrifuge

Relatively low-cost simulator, to be finished at SISD by June, will have four-man capsule for 30-day tests; second capsule to be added

CONSTRUCTION is about to begin on what North American Aviation, Inc., claims will be the world's largest and most versatile simulator of the stresses upon human subjects of prolonged rotation in an artificial gravity spacecraft. It is to be completed and in service at NAA's Space & Information Systems Div., Downey, Calif., next June.

The centrifuge-like facility will consist of a four-man capsule capable of carrying food and water for tests lasting up to 30 days. The designed capsule can be placed at various distances from the hub of the 75-ft.-radius beam upon which it is mounted. At first, a variable-weight concrete and water mass will be carried on the opposite beam to counterbalance the weight of the manned capsule. However, NAA plans to install another capsule there later so that two sets of subjects can be tested at once.

Hydraulic jacks outboard of the capsule will be used to bank it at angles up to 30 degrees so that the apparent gravity vector can be made perpendicular to the floor at various radii and rates of rotation. It is not intended to produce high accelerations; the design limit is 2g radial. The present experimental plan calls for a maximum of only 1.4 g for the resultant of radial and vertical forces.

The 75-ft. radius was selected because preliminary conclusions indicate that it may be the smallest physiologically acceptable; spacecraft cost considerations dictate that radius of rotation should be as small as possible. One goal of the first behavioral studies scheduled for the facility is to determine whether work tasks, operating techniques and training methods can be revised to make smaller spacecraft acceptable. There are plans to lengthen the beam semispan (radius) to 125 ft. at some time in the future, in order to study the opportunities and problems created by increasing the size of spacecraft.

● **Low cost**—The Rotational Research Facility, as it is called, is being paid for with money from NAA technical overhead—and at relatively low cost. The price has been set at $430,000 in the initial configuration. Total weight of structure in the facility will be about 300,000 lbs. The capsules are fuselage sections from surplus Air Force KC-97 tankers. The Air Force let NAA have them for shipping charges, thereby saving about $20,000 per capsule.

To collect information on which to base the design of the equipment and plan the experimental program, North American first ran a couple of three-day experiments at low speed on the small, 23-ft.-radius manned centrifuge of the University of Southern California. The first experimental program with the new facility will be a company-funded series of nine seven-day tests.

● **Hazard to vision**—The first program is to measure psycho-physiological ability to perform tracking and monitoring tasks in a rotating spacecraft and to see what effect rotation has upon the powers of vision.

In the brief preliminary tests at USC, a subject who had apparently adapted to rotation quickly and well attempted to read a book and began to vomit after 20 minues. He was a former Marine Corps aviator and highly motivated, qualifications which usually correlate with good tolerance of this type of stress. The single test is no basis for a conclusion but NAA investigators believe it marks an area for research.

The USC tests indicated that, in general, people do adapt to rotation. One of the main biomedical goals of the NAA program will be to establish normal rates of adaptation and the effect upon them of design factors such as rate and radius of rotation. It is still possible at this stage of the game to make trade-offs between mission plans and hardware design. It would be a mistake to make the astronaut workload too heavy when adaptation is incomplete. If critical events cannot be postponed, it would indicate a need for automatic equipment. NAA will also study the effectiveness of symptom-preventing drugs.

● **Coming back**—The preliminary runs suggest that readaptation to nonrotation occurs within two or three hours, but is accompanied by some of the unpleasant symptoms of the original adaptation. The exact nature and duration of these and the factors that may modify or amplify them will receive attention at the NAA facility. Readaptation is an important area of study because in an emergency escape or in a ferry operation astronauts very probably would be in the process of readapting. If the symptoms are serious and uncontrollable, the hardware for these purposes would have to function automatically.

One of the physiological phenomena of interest to experimenters is the "oculogyric effect." It is familiar to military pilots, who know that if one turns his head toward another airplane in a formation he will unconsciously tend to turn his aircraft in the same direction. The experienced pilot has learned to compensate for the effect without thinking about it or to avoid such head movements. It remains to be seen whether this will work in a rotating spacecraft.

● **Coriolis effect**—A major unknown to be evaluated is the Coriolis effect, an apparent force produced by the fact that when an object is moved from one point toward another in a rotating field, the target swings away from its original position as the object is en route. Thus, anything moved about in a rotating spacecraft will tend to move in a curved line with respect to everything tied down in the spacecraft. A seated man attempting to rise will feel a tendency to leap headlong at the wall. It could also upset the mechanism of balance in the inner

ear as the astronauts attempt to move about the spacecraft.

NAA experimenters will face a familiar difficulty of space simulation: the simulator cannot be freed of Earth gravity. The body axes of subjects will not be parallel to the plane of rotation, as they would be in an actual space station. Because of this, Coriolis force sensed in the inner ear of a subject will not vary with radius and rate in the same way that it would in a space station. NAA is about to begin a computed program to calculate the relationship between Coriolis force at the inner ear and the radius and rate set up in the Rotational Research Facility. It will then be possible to correlate results directly with the apparent force.

Since the capsules are straight tubes, the radius of rotation at the ends is greater than at the center, particularly when the capsule is positioned close to the hub for short radius runs. The ideal shape would be a tube curved to match the circle it travels. The gradient in the simulated gravity produced in straight sections could be a hazard to the validity of the data but it can also be converted to an advantage.

Biomedical experts are concerned about possible cardiovascular effects of gravity gradients. With the straight cabin they can place an experimental subject at one end and a control subject in the center to determine whether the slight difference in radius produces a measurable effect. Since radial acceleration produced by the facility can be controlled within 0.01g and speed can be controlled within 0.4%, it should be possible to evaluate small variations.

• **Second capsule thoughts**—Facility engineers are considering a stepped floor for the second capsule and the positioning of equipment and storage spaces so that the inhabitable area is all at an approximately equal distance from the hub. A sealed cabin and other features of a true spacecraft are also under consideration for the second capsule, so that the cumulative effects of other stresses of space travel can be imposed in controlled combinations.

No firm decisions have been made on these installations because project personnel still have to go through the cost trade-offs. Installation and removal of equipment to meet varying experimental requirements is a relatively simple matter, because of the large cargo hatch in the KC-97 fuselage sections.

Since the weight of the payloads can range widely, Rucker Co., the facility construction contractor, designed a modular electric-hydraulic drive that can be matched to the power requirement by varying the number of 50-hp. motor-pump modules grouped at the foot of the support mast. Up to 16 may be installed for a maximum of 800 hp. ■

TACTICAL MISSILES

Extensive activity in the development of tactical missiles offers a variety of opportunities to engineers and scientists. Specifically, these opportunities are in the following fields:

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Conduct analytical and experimental studies to determine basic aerodynamic characteristics of advanced tactical missile designs. Establish propulsion system requirements using estimated aerodynamic characteristics.

FLIGHT DYNAMICS

Initiate and conduct advanced analyses in flight dynamics and dynamic behavior of closed loop systems with the aid of analog computers and dynamic flight simulators for determining advanced tactical missile design requirements.

DESIGN INTEGRATION

Conduct preliminary design integration studies including interface compatability, logic, information flow and power distribution. Conduct preliminary vehicle sizing with a working knowledge of trajectory analyses, propulsion performance and component design.

VIBRATION AND FLUTTER

Conduct vibration and flutter analyses of advanced tactical missile configurations. Develop advanced analytical techniques for determining vibration and flutter characteristics.

PROPULSION

Originate and conduct analyses of advanced tactical missile propulsion system including solid, liquid and hybrid rocket engines and air breathing systems. Investigate new propulsion concepts and determine applications for advanced tactical missiles.

GROUND SYSTEMS

Formulation of requirements and preliminary system design of automatic and semi-automatic electronic checkout equipment for missile and ground systems. Determine requirements for missile handling and service equipment including mechanical, electromechanical, electrical, and fluid systems.

ORDNANCE

Perform analysis, preliminary design and integration of warheads and conceptual mechanizations for fuzing systems for nonnuclear and nuclear warhead systems.

FLIGHT MECHANICS

Initiate and conduct studies to develop methods for determining the trajectory which maximizes a desired trajectory characteristic for a given set of constraints. Requires a strong background in mathematics, including a working knowledge of the calculus of variations, gradient methods, and dynamic programming.

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So it goes in the re-entry systems business at General Electric.

The road ahead is even tougher. For one thing, ballistic missile weapons must perform more complex missions. For another, the General Electric re-entry drive is not confined to ballistic flights. Early in the business, using the Mark 2 as a laboratory, we began gathering important scientific information. Then our Nuclear Emulsion Recovery Vehicle (NERV) explored deep into the Van Allen Belt. There was the Discoverer program, resulting in the world's first successful recovery from orbit. We're working currently on the Biosatellite. Studies of maneuverable return-from-orbit re-entry vehicles are under way. Not far into the next generation lies the development of re-entry systems technology to the stage of multi-place ferries and space station taxis. We're thinking about them now.

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The Industry Week

Mergers and Acquisitions

Computer Sciences Corp., El Segundo, Calif., has announced plans to acquire two subsidiaries of International Telephone and Telegraph Corp., ITT Communications Systems, Inc., and ITT Intelcom, Inc. The two ITT operations will continue in their present activities as wholly owned subsidiaries of CSC, along with Documentation, Inc., another recent CSC acquisition (M/R, Nov. 9, p. 47). ITT Communications Systems, Inc., headquartered in Paramus, N.J., has been performing management specialist and systems engineering work for the Air Force and Dept. of Defense. ITT Intelcom, Inc., Falls Church, Va., performs engineering and systems management services in the field of communications satellites. ICS and Intelcom personnel are to be retained in their present positions. . . . *Nuclear Data, Inc., Palatine, Ill., has acquired Instrument and Development Products Co. of Chicago. ND designs and manufactures multichannel analyzers and signal averaging digital computers with applications in nuclear physics, electrophysiology, spectroscopy, radar astronomy, and other scientific areas. I&D P makes automatic sample changers for counting beta and gamma samples, nuclear counting instruments, specialized stands for positioning detectors in diagnostic medical studies, lead shields and manual sample changers for use with scintillation detectors. The acquisition is an effort to expand the product line in the nuclear instrumentation field.* . . . Teledyne, Inc., Hawthorne, Calif., will buy United ElectroDynamics, Inc., Pasadena, Calif., a firm engaged in the seismology and geophysics fields. . . . *General Precision Equipment Corp., Tarrytown, N.Y., has reached agreement to acquire for 417,583 shares of its common stock EDO Corp. of College Park, N.Y. EDO designs and manufactures electronics equipment, specializing in the fields of LORAN and undersea navigation, sonar and underwater acoustics.* . . . Glass-Tite Industries, Inc., Meadville, Pa., has signed an agreement to purchase for an undisclosed amount of cash Dytronics, Inc., of Leesburg, Ind., a manufacturer of a patented line of stamped metal circuits.

New Activities

Union Carbide Corp., New York City, has formed a new Electronics Department, the manager of which will be responsible for the Kemet Dept., the Crystal Products Dept. and two UC subsidiaries, the Korad Corp. and Data Systems, Inc. Kemet produces electron tube "getters," solid tantalum capacitors and n- and p-channel field effect transistors, amplifiers and integrated circuits. Korad Corp. develops and markets laser equipment; Data System, develops and markets computer industrial control units. . . . *Digitronic Corp., Albertson, N.Y., has formed a new OEM-Industrial Div. to handle sales of its digital systems and components, including the company's tape readers and tape handlers, Dial-o-verter terminals and systems and Data-Verter systems. The division will also offer a custom-built component service which will develop special hardware to cover a variety of systems applications.* . . . Super-Temp Corp. Santa Fe Springs, Calif., has established Metallurgical Services Laboratories to provide industry a wide range of testing, quality control and consultation services on a long-range contract or per job basis. MSL offers extensive studies in heat treatment, brazing, process development and process feasibility, in addition to materials testing.

Missile/Space Facilities

Lockheed Propulsion Co., Redlands, Calif., is nearing completion on a new cast-and-cure station at its Potrero Production and Test Facility. The station is value-engineered to reduce the time required and the need for heavy equipment to handle 156-in.-dia. motor segments, which weigh more than 100 tons when loaded with propellant. . . . *Defense Electronics, Inc., has consolidated the activities of its five operating plants in a new 85,000-sq.-ft. building in Rockville, Md. Cost of the new facility is $1 million. DEI manufactures products for use in telemetry and space communications.* . . . Honeywell, Inc., is to begin construction soon on a 65,000-sq.-ft., multi-million-dollar electronics facility near Tampa, Fla. Work at the plant is to involve manufacture of "new types of electronic systems and components of several types requiring facilities not now existing within Honeywell." . . . *Parker-Hannifin Corp., Cleveland, plans to build two new facilities, one in Lewisburg, Ohio, and the other at Plymouth, Mich. The 3,000-sq.-ft. Lewisburg plant is part of an expansion of the Parker Fittings and Hose Co. Div. The Michigan building will serve as a warehouse and service center for Parker-Hannifin industrial fluid system products marketed in the Detroit area. The Cleveland-based firm is a major manufacturer of hydraulic, pnuematic and fluid system components for industrial, aerospace and consumer applications.*

Company Representatives

Loral Electronic Systems, The Bronx, N.Y., has appointed two new manufacturer's representatives to handle its line of solid-state microwave filters and amplifier devices. The firms are Spacetronics Co., Dallas, and Burgin-Kreh Assoc., Towson, Md., and Philadelphia. . . . *IMC Magnetics Corp., Westbury, N.Y., has appointed Berndt & Klein Associates, Inc., Chicago, engineering sales representatives for Illinois, Wisconsin and Iowa. B&K will handle IMC standard and step-servo motors, solenoids, synchros and related devices.* . . . Branson Corp., Whippany, N.J., has named Elsner-Rambo Co., Los Angeles, to handle California and Arizona sales of its line of magnetic relays and timing modules.

contracts and procurements

AWARDS

AIR FORCE

$10,650,000—**Radio Corp. of America,** Moorestown, N.J., for modification of the Ballistic Missile Early Warning System (BMEWS).

$6,489,819—**U.S. Underseas Cable Corp.,** Washington, D.C., for fabrication and installation of a communications cable linking Hawaii and Johnston Island in the South Pacific.

$3,500,000—**McDonnell Aircraft Corp.,** St. Louis, first part of a $40-million contract for a feasibility study of a boost-glide re-entry vehicle.

$3,353,042—**Space-General Corp.,** El Monte, Calif., for fabrication, assembly and checkout of space vehicles.

$2,218,416—**Allied-Shaffer,** South Gate, Calif., for hardened communications antenna facilities at Malmstrom AFB, Mont.

$2,200,000—**General Precision, Inc.,** Little Falls, N.J., for flight-feasibility test program on a stellar inertial guidance system.

$1,900,000—**International Business Machines Corp.,** New York City, to install a computer system at the Air Force Cambridge Research Laboratories for support of basic and applied research programs in the physical and environmental sciences.

$1,550,000—**The Hallicrafters Co.,** Chicago, for penetration aids development.

$759,000—**The Hallicrafters Co.,** Chicago, follow-on for a classified program.

$83,000—**Bissett-Berman Corp.,** Santa Monica, Calif., for experimental R&D contract to investigate the optical properties of various materials and to develop fast, passive, protective optical filters.

$49,000—**Allegany Instrument Co.,** Cumberland, Md., for electronic instruments.

$40,000—**Hughes Aircraft Co., R&D Div.,** Culver City, Calif., for research for thermophototropic temperature control coatings for the space environment.

$39,884—**General Electric Co., Missile and Space Div.,** Valley Forge, Pa., for investigation of the effects of molecular contaminants on RF-induced plasma shield propagation.

$34,079—**Space-General Corp.,** El Monte, Calif., for sounding rocket vibration studies.

ARMY

$7,515,212—**Philco Corp.,** Newport Beach, Calif., incremental funding for *Shillelagh* research and development.

$5,600,000—**Philco Corp.,** Newport Beach, Calif., for *Shillelagh* production engineering services.

$1,946,000—**Rohn and Haas Co., Redstone Arsenal Research Div.,** Redstone Arsenal, Ala., for a program of exploratory design and development of solid and hybrid rockets and propulsion.

$1,400,000—**General Dynamics Corp.,** Pomona, Calif., for FY 1965 *Redeye* research and development program.

$700,000—**Infrared Industries, Inc.,** Santa Barbara, Calif., for production of electro-optical devices for *Redeye*.

$453,296—**Keeling Bros. Construction Co.,** Richardson, Tex., for *Nike-X Sprint* launch facility at White Sands Missile Range.

$370,000—**ITT Federal Laboratories,** Nutley, N.J., for Type II Satellite.

$135,000—**Philco Corp., Aeronutronic Div.,** Newport Beach, Calif., for 12-month range study at Kwajalein test site for Nike-X project office.

$92,895—**Raytheon Co.,** Andover, Mass., for replenishment repair parts for *Hawk* missile system.

$40,205—**Hughes Aircraft Co.,** Fullerton, Calif., for *Nike-Hercules* radar feasibility study.

$32,656—**Northrop Corp.,** Anaheim, Calif., for remanufacture and update of *Hawk* loader-transporter.

$30,130—**Northrop Corp.,** Anaheim, Calif., for engineering services for *Hawk* loader-transporter.

The Hicks Corp., Asheville, N.C., for M30 rocket motor case and gas generator (amount undisclosed).

NAVY

$4,958,062—**Hercules Powder Co.,** Wilmington, Del., for research and development on second-stage *Polaris* motors.

$2,093,750—**North American Aviation, Inc.,** Canoga Park, Calif., for continued work on rocket motors for *Shrike* air-to-ground missile.

$750,000—**Fairchild Camera and Instrument Corp., DuMont Laboratories,** Clinton, N.J., for submarine radar equipment.

$623,000—**North American Aviation Corp., Rocketdyne Solid Motor Div.,** McGregor, Tex., for solid-propellant gas generators for *Tartar* and *Terrier* missiles.

$95,000—**Bunker-Ramo Co., Defense Systems Div.,** Canoga Park, Calif., for a hybrid computer study that may lead to definition of standard Navy computer of the future.

NASA

$2,600,000—**Lear Siegler, Inc.,** Santa Monica, Calif., follow-on contract for electronic systems for the Marshall Space Flight Center.

$1,000,000—**Computer Applications, Inc.,** New York City, for off-site computer programming services.

$383,500—**Martin Marietta Corp.,** Denver, for development of advanced light pressurization system for current *Apollo* service propulsion system.

$365,000—**Ling-Temco-Vought, Inc.,** Dallas, to test *Apollo* and *Gemini* prototype space suit assemblies which include pressure suits and life-support systems under extreme heat and cold conditions in a vacuum.

$355,000—**McAlester & McQuinn Construction Co.,** Huntsville, Ala., for installation of activation hardware on *Saturn* static test facility at Marshall Space Flight Center.

$284,112—**Geophysics Corp. of America,** Bedford, Mass., for investigation of the dynamics and physics of the ionosphere at high latitudes.

$199,838—**The Boeing Co.,** Aero-Space Div., Seattle, for a study of the operational aspects of mission requirements of lifting systems.

$196,709—**TRW Space Technology Laboratories,** Redondo Beach, Calif., for a trajectory study for advanced lunar missions.

$145,374—**The Boeing Co.,** Seattle, for analysis of experimental aerothermodynamic data obtained during the *X-20* program.

$93,000—**Martin Marietta Corp., Baltimore Div.,** Baltimore, for development of lunar hand tools.

$71,705—**Ling-Temco-Vought, Inc.,** Dallas, for a study of an unguided solid-fuel rocket vehicle with solar-orbital capabilities.

$60,269—**Stanford Research Institute,** Menlo Park, Calif., for studies to determine information requirements for guidance and control system.

$49,000—**International Business Machines Corp., Federal Systems Div.,** Bethesda, Md., for computer programming services.

$48,570—**Lockheed Aircraft Corp.,** Burbank, Calif., for a light ion mass spectrometer experiment, associated equipment and support for *OGO-E*.

$44,875—**Vego Precision,** Vienna, Va., for a radar transponder.

$40,000—**Union Carbide Corp., Carbon Products Div.,** Parma, Ohio, for high-temperature protective coatings for refractory metals.

$39,995—**Melpar, Inc.,** Falls Church, Va., for a gas chromatograph instrument.

$27,000—**University of Texas,** Southwestern Medical School, Dallas, for a biosatellite project experiment on the influence of zero-gravity on isolated human cells.

$26,610—**Thiokol Chemical Corp.,** Elkton, Md., for rocket motors.

Cosmic, Inc., Washington, D.C., for the development of a charged particle source for an electric propulsion engine (amount undisclosed).

INDUSTRY

$2,300,000—**Simplex Wire and Cable,** Newington, N.H., from **U. S. Underseas Cable Corp.,** Washington, to provide cable for the communications project linking Hawaii and the Johnston Islands in the South Pacific undertaken for the Air Force.

$550,000—**Textron Inc., Bell Aerosystems Co.,** Buffalo, N.Y., from **The Boeing Co.,** Seattle, to build rocket propellant tanks for the camera-carrying *Lunar Orbiter* spacecraft.

$455,000—**Thiokol Chemical Corp., Astro-Met Div.,** Bristol, Pa., from the **Sandia Corp.,** Albuquerque, N.M., to build 48 *Tomahawk* sounding rocket vehicles and associated equipment.

$165,000—**Electro-Optical Systems, Inc.,** Pasadena, Calif., from **General Precision, Inc.,** Link Div., Palo Alto, Calif., for design and construction of a data recovery subsystem for a spacecraft television ground data-handling system to support the *Surveyor* project.

$175,000—**Swedlow Inc.,** Garden Grove, Calif., from **Hercules Powder Corp.,** Bacchus, Utah, for an undisclosed number of reinforced plastic rocket nozzle thrust terminators for the Air Force *Minuteman* ICBM (amount undisclosed).

Allis-Chalmers, Milwaukee, from **North American Aviation, Rocketdyne Div.,** Canoga Park, Calif. for equipment to be used in a spin test pit.

REQUESTS FOR BIDS

GENERAL PROCUREMENTS

NASA Manned Spacecraft Center
General Research Procurement Branch
2101 Webster-Seabrook Road
Houston, Texas 77058
Attn: Hilda Bolling

Program to determine by means of a controlled experiment using a hyper-velocity ballistic range the ionizing efficiency of artificial meteors, one study. RFP BG751-28-5-231P, due date Dec. 10, 1964.

NASA Manned Spacecraft Center
General Research Procurement Branch
2101 Webster-Seabrook Road
Houston, Texas 77058
Attn: Hilda Bolling

Negotiations will be conducted with Midwest Research Institute, Kansas City, Mo., for development of a computer program for determining the absorbed incident external thermal radiation to the *Apollo* spacecraft. For information only; RFP not available.

Purchasing Office
George C. Marshall Space Flight Center
Huntsville, Alabama 35812

NASA proposes to issue RFQ 2-5-01-04146-01 on or about Nov. 18, 1964, with a period of thirty days to be allowed for submission of proposals. Contractor must furnish labor, materials, equipment and facilities for the fabrication, assembly, inspection and testing of three each *Saturn* S-1C stage transporters complete with wheel units, wheel unit actuators and control system.

NASA Manned Spacecraft Center
General Research Procurement Branch
2101 Webster-Seabrook Road
Houston, Texas 77058
Attn: Hilda Bolling

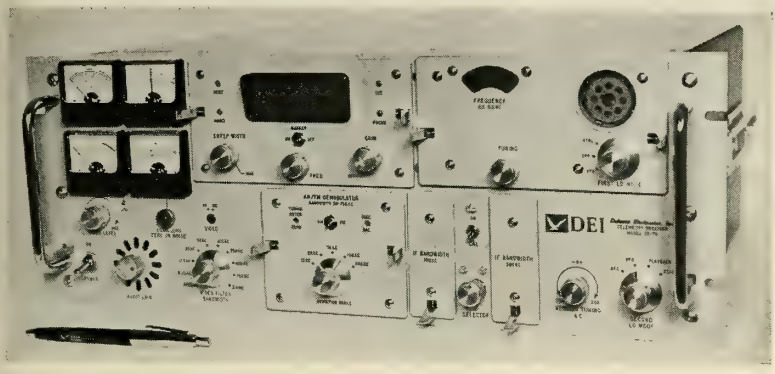
Negotiations will be conducted with Beckman Instruments, Inc., Fullerton, Calif., for a standard product dextir data acquisition system. For information only, RFP not available.

National Aeronautics and Space Administration
Headquarters
Washington, D. C.

Launch vehicle-oriented programming and computer services. NASA is negotiating with C.E.I.R. Inc., Arlington, Va. For information only, RFP not available.

George C. Marshall Space Flight Center
Huntsville, Alabama 35812

Research study in the man-rating of *Saturn* launch vehicle system will be negotiated by the center with the Goodyear Aerospace Corp. for the continuation of a previous contract. For information only, RFP not available.



New Product of the Week:

Solid-State Receiver

A solid-state telemetry receiver, said to be virtually free of spurious signals and offering an order of magnitude improvement in strong signal handling capabilities, has been introduced by Defense Electronics, Inc.

The TR-711 is modular in construction and can be supplied with a complete complement of plug-in modules. These include: RF tuning units from 100 to 2,300 mc; IF amplifiers with 10-kc to 3.3-mc bandwidths; AM, FM and phase demodulators and a spectrum display unit. Any combination of modules can be utilized.

A rear apron 30-mc IF input connector allows the device to be used as a 30-mc "receiver" in conjunction with any tuning unit or device having a 30-mc output frequency.

Circle No. 151 on Subscriber Service Card

Antenna Feed

Jasik Laboratories, Inc., has developed a multiple-function antenna feed which combines telemetry transmit, receive and radar tracking into a single unit.

The Model 283 operates in the 1.7 to 2.95-gc band. It uses a noncontacting rotary joint which incorporates an isolation choke to shield stainless steel support bearings. The telemetry transmit has power up to 10 kw in the 1.7 to 1.85-gc band. In the receive mode, the passive track has a crossover level of approximately 1.0 db in the 2.2 to 2.3-gc band. With the radar track, power is up to 1.0 megawatt peak, 500 watts average (active). Crossover level is approximately 1.25 db. When used in a radome, the system may be sealed and pressurized to 15 psig.

Circle No. 152 on Subscriber Service Card

Frequency Converter

A three-phase frequency converter, measuring 14 in. high, has been introduced by CML, Inc., a subsidiary of Tenney Engineering, Inc.

The Model T2500A is rated at an output of 2,500 va. Frequency range is 45 to 6,000 cps. The unit is available with plug-in oscillators in fixed or adjustable frequencies. Output is adjustable from 0 to 125v, Y or Δ. Response time is 50 microsecs.

Circle No. 153 on Subscriber Service Card

Shielding Material

Reactor Experiments, Inc., is marketing a line of polyethylene-boron bricks, especially designed to shield against high thermal neutron fluxes.

The bricks have a specific gravity of approximately 0.92 g/cc and contain the equivalent of 5 weight percent of boron in the form of a boron compound. A 4-in. thickness of this material will attenuate thermal neutrons by a factor of approximately 2 x 10^6. The bricks are available in standard sizes of 2x4x8 in. and 4x6x8 in. Other sizes and percentages of boron are available on special order.



Circle No. 154 on Subscriber Service Card

Code Generator

A group of serial digital code generators capable of generating a pulse series of up to 32 digits at any specified pulse pacing between 0.2 and 2 microsecs, is now available from Computer Devices Corp.

The generators use magnetostrictive delay lines, available either as tapped delay lines or supplied with transistorized amplifiers and shapers for restoration of the signal to input logic level. Amplified output pulses have rise times of less than 0.05 microsecs; pulse spacing is set to an accuracy of better than 0.02 microsec.

The Model DM718 provides 12 digits spaced at 1.25 ±0.02 microsecs, and a total delay capability of 15 microsecs. It measures 1.75 x 0.5 x 8 in.

Circle No. 155 on Subscriber Service Card

Isometric Comparator

Stocker & Yale, Inc., is marketing a dual-image isometric comparator, designed to speed up operations when checking or adjusting straightness or alignment in two planes simultaneously.

The instrument consists of two lens and illumination systems and two viewing screens. Two views of the same subject—90 degrees apart—are projected simultaneously onto separate screens. Magnification ratios and screen sizes and proportions vary according to customer specifications.

The unit requires approximately 3 sq. ft. of bench area. A production rate of 200 to 400 pieces per hour for simple adjustment and alignment checking may be maintained.

Circle No. 156 on Subscriber Service Card

Frequency Multiplier

Somerset Radiation Laboratory, Inc., has developed the Model X915 frequency-multiplier power source. It is said to be capable of driving a step-recovery multiplier to yield an output of 1 mw at X-band from 8.2 to 12.4 gc.

Circle No. 157 on Subscriber Service Card

Check Valve

A series parallel check valves, developed especially for the *Apollo* program and available for similar fuel pressurization systems, has been announced by Accessory Products Co., a

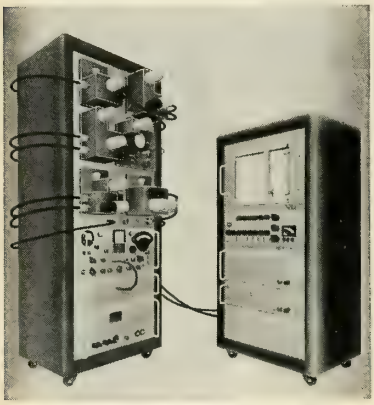
division of Textron, Inc.

The valve provides for flow of gas in one direction only. As used in the *Apollo* program, a single helium source pressurizes the fuel (UDMH or MMH) and oxidizer (N_2O_2) tanks through two of these valves.

Circle No. 158 on Subscriber Service Card

Spectrum Scanner/Plotter

White Electromagnetics, Inc., has announced an automatic spectrum scanning and plotting system, the Auto-Spectrum Plotter, available in several configurations.



In one configuration of the Model 120A, the frequency spectrum from 100 cps to 1,000 mc is automatically scanned through 15 bands in 3 minutes. A 40-db signal or interference dynamic range is plotted out on a 5x3 intensity versus frequency matrix. Individual bands of interest may be plotted full scale for finer resolution.

Also available are an accommodation for the incorporation of the 1 to 10-gc spectrum, provisions for increasing the dynamic range from 40 to 80 db, and spectrum scan times up to several hours.

Circle No. 159 on Subscriber Service Card

Line-Voltage Regulator

Sola Electric Co. has available a Solatron line-voltage regulator, designed for military applications and meeting MIL-R-23098 specifications.

The SPR-400 is available in 1, 5, 10, 15 and 25-kva models. It has a frequency of 400 cycles and input voltage of 115v ±5%. Output is 115v, ±0.5% adjustable. The device operates in ambient temperature up to 50°C.

Circle No. 160 on Subscriber Service Card

Thermal Conductivity Unit

A 2,500°F guarded hot plate thermal conductivity instrument, meeting ASTM specification C177-63, is being manufactured by Dynatech Corp.

The Model TCFG-R25-4V measures two samples, 7.5 in. sq., from room temperature to 2,500°F or from −300° to 2,500°F when an optional liquid nitrogen system is incorporated. Accuracy is ±2% from 75° to 800°F, ±5% from 800° to 1,800°F, and ±10% from 1,800° to 2,500°F.

Heat source consists of nine blocks 2.5 in. sq., wound with a resistance heating element. Maximum heat flux is 10,000 BTU-hr.-ft.^{2} Input is 110v ac, 60 cps.

Circle No. 161 on Subscriber Service Card

Parametric Amplifier

A low-noise parametric amplifier, cooled either to liquid nitrogen (77°K) or liquid helium (4°K) for satellite communications, is available from Microwave Physics Corp.

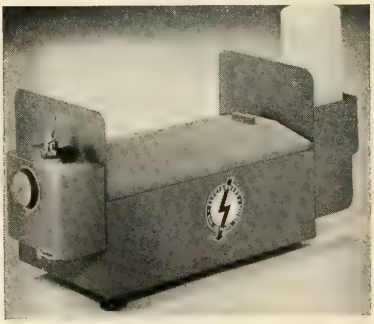
The Model C-4 is tunable from 3.7 to 4.2 gc. It has typical noise temperature of 64°K when cooled to 77°K and 20°K when operated at 4°K. Bandwidth is 30 mc at the 1-db points; gain is nominally 15 db.

The unit is normally supplied with a liquid nitrogen dewar, fill tube and overflow tube. One charge of nitrogen will last 48 hrs. The assembly is tiltable ±52° for mounting directly at the antenna feed. Phase and gain stabilities are ±2° and ±0.1 db per hour, respectively.

Circle No. 162 on Subscriber Service Card

Foam Fluxer

Electrovert, Inc., has developed a foam fluxing unit, said to be easily adaptable to the straight-line operation of various wave-soldering systems.



The unit is available with a 10 or 12-in.-wide foam crest. It is constructed of stainless steel and coated with Teflon to accommodate all types of foam fluxes. The tank is equipped with a feeder bottle for continuous flux application and can be disassembled for cleaning.

In operation, a uniform, quick-wetting foam layer of constant bubble size and burst is produced. As the printed circuit board passes over the foam crest, the entire underside of the board is coated. An adjustable metering valve and regulator gauge step-down and regulate the air pressure to permit control of bubble size and foam height.

Circle No. 163 on Subscriber Service Card

Input Sine Converter

Spectral Dynamics Corp. has developed a vibration test instrument called the SD-103 Dynamic Input Sine Converter (DISC). The phase-coherent unit accepts a variety of repetitive input wave forms and produces a sine wave output of the exact frequency, phase-locked with the input signal.

The DISC performs the following five functions: rotating machinery vibration analysis; tracking function generation; frequency to dc conversion, over a range of 10 cps to 10 kc with a linearity exceeding 0.25%; constant output amplification, accepting signals from 25 mv to 65v RMS; and signal conditioning.

Circle No. 164 on Subscriber Service Card

Temperature-Power Control

A solid-state temperature controller with an SCR power regulator for closed-loop control of temperature is available from Research, Inc.'s Controls Div.

The LABAC A has an input of 115 to 230v ac and a receptable for the oven load. In operation, the operator dials a set-point temperature which unbalances a zener-regulated bridge network. Bridge output is amplified to drive a magnetic SCR firing circuit to apply full-line voltage to the oven. When the set point is reached, the oven voltage reduces proportionally to the level necessary to maintain the set point.

Standard models are rated for 10 to 20-ampere loads. A line of platinum resistance sensors is available for a temperature range of −260° to 500°C.

Circle No. 165 on Subscriber Service Card

Percussion Welder

A percussion welder, basically designed for attaching thermocouples to metal specimens of any size or material, is available from Duffers Associates, Inc.

The Model 310 accommodates wire sizes up to 0.04 in. Single-knob control switches the power supply through eight range settings from 30 to 245v. Charge times are 1.5 secs. on the first setting to 12 secs. on the eighth setting. Input is 110v ac.

Circle No. 166 on Subscriber Service Card

Gas Laser Projector

Bausch & Lomb, Inc., is marketing a gas laser projector for demonstration and experimental use.

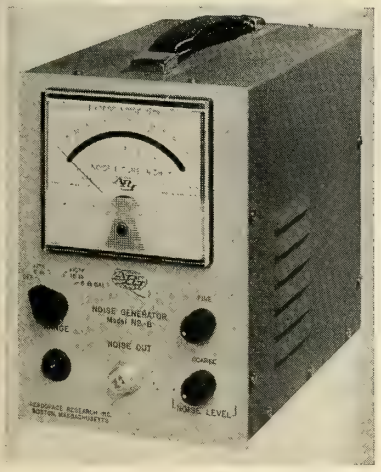
The projector unit consists of a

laser tube filled with a helium neon gas mixture, tube housing and power supply. Output is a linearly polarized monochromatic beam at 6,328 Angstroms from each end of the unit. Power unit is a 27-mc radio frequency oscillator. The laser cavity consists of a plano mirror and a 500-mm radius concave mirror spaced at slightly less than 500 mm.

Circle No. 167 on Subscriber Service Card

Random Noise Generator

A random noise generator featuring servo stabilized output to better than 0.05 db over a line voltage range of 90 to 130v is being marketed by Aerospace Research, Inc.



The Model NS-B RF generator has a temperature range of —20° to 140°F. The servo stabilization is said to eliminate the long warm-up time inherent in temperature-limited thermionic diode systems. The device provides a scale of excess noise output in °K and has a frequency range of 1 to 500 mc.

Circle No. 168 on Subscriber Service Card

Infrared Thermometer

An infrared thermometer for noncontact temperature measurement in the 150° to 750°F range is being marketed by Ray-Tek, Inc.

The Model R-7 features an optical sight with reticle for accurate alignment and focusing, a spot size of 0.1 in., response time of 10 millisecs., and the ability to make measurements through a glass window. An electrical output is provided for recording and control. Direct temperature readings are provided on a calibrated meter.

Circle No. 169 on Subscriber Service Card

Portable Gamma Alarm

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III PERT & TIME
IV HOW PERT PLANS
V HOW PERT CONTROLS
VI BUILDING PERT
VII WHAT IS NETWORKING
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IX MEASURING MANAGEMENT RISK
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XI PERT COSTS & COMPUTERS
XII PROFIT PERT & INCENTIVES
XIII PERT DATA DISPLAY

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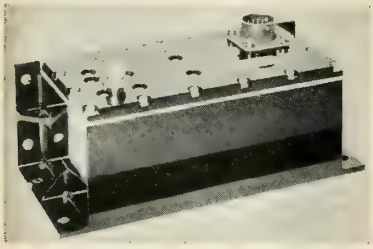
lation-type detectors, is being marketed by Nuclear Measurements Corp.

The GA-2TP is not affected by external electromagnetic or electrostatic fields and will not jam in extremely high-level radiation, the firm says. Power is supplied by nickel-cadmium batteries or D-size flashlight batteries. The unit offers indicating ranges of 3, 4 or 5 logarithmic cycles, calibrated in mr/hr or r/hr. It is housed in a sealed shock-mounted cabinet measuring 15 x 7 x 8 in. Weight is 11 lbs.

Circle No. 170 on Subscriber Service Card

Command Receiver

An all-silicon, transistorized command receiver, for use in controlling drones and pilotless aircraft and for destroy purposes in missile range-safety operations, is being marketed by Leach Corp.



The Model FMR-303 operates in a temperature range of —40° to 85°C. According to Leach, use of improved transistors enables the receiver to operate with greater reliability at elevated temperatures—approximately 10°C higher than germanium transistorized units. The unit is designed to receive up the three tone-modulated FM signals in a 406 to 450-mc frequency range. Frequency deviation is ±30 kc per channel. Sensitivity is 2 mv.

The device measures 48 cu. in. and weighs 54 oz. It can withstand shocks of 100 g's and vibrations of 20 g's to 2,000 cps.

Circle No. 171 on Subscriber Service Card

Fiber Optic CRT

Two cathode ray tubes with fiber optic faceplates for making photographic reproductions of their outputs are available from Westinghouse Electric Corp.'s Electronic Tube Div.

The Model WX-30038 has a 4-in.-dia. fiber optics faceplate. This tube uses magnetic deflection and electrostatic focusing and has a usable screen of 3.2 in. dia.

The Model WX-5321 is designed for line scanning. Overall diameter of the face is 5.25 in. The optical fiber band has a usable length of 4.25 in. and width of 0.25 in.

Both tubes have a spot size of 0.0008 in. and potted leads for high voltage protection.

Circle No. 172 on Subscriber Service Card

Electrometer

Victoreen Instrument Co. has announced a vibrating reed electrometer, the Model 474 Series Picometer.



The unit's dynamic capacitor provides full-scale indication for currents in the 10^{-14}-ampere range and voltages from 10 mv. Ranges in the series are 10, 30, 100, 300, 1,000mv and 3, 10 and 30v; 32 current ranges from 3 x 10^{-14} to 10^{-7} ampere are provided by choice of four Hi-Meg resistors. Stability is less than 10% full scale drift in 24 hours.

Circle No. 173 on Subscriber Service Card

Programming Switch

An Actan programming switch, featuring a removable memory drum for instantaneous program changes, is being marketed by Sealectro Corp.

The device is available with drum sizes from 36 to 120 positions, controlling from 6 to 51 circuits. It may be manually or remotely operated by solenoid or timing motor. The drums are adjustable, providing complete flexibility of programming at any time by sliding the actuators along in the grooved drum to the desired program pattern, the firm says.

Circle No. 174 on Subscriber Service Card

Feed-through Ring

NRC Equipment Corp. has developed a multi-port vacuum feed-through ring, said to enable introduction of many more electrical, mechanical or fluid controls into a vacuum chamber than is possible with a typical base plate installation.

The Model 1505 is available in stainless steel or cast aluminum in four sizes: 12-, 14-, 18- and 24-in. diameter. Depending on ring size, there are 10, 12, 16 or 20 ports, all 2.25 in. in diameter. A total of 26 feed-throughs are available for use with each ring.

Circle No. 175 on Subscriber Service Card

Capacitance Bridge

A 100-kc bridge providing capacitance measurements from 0.0002 to 110,000 pf with a basic accuracy of 0.1% is available from Boonton Electronics Corp.

The Model 74D also measures conductance from 0.001 to 1,000 micromhos and shunt resistance from 1,000 ohms to 1,000 megohms. The instrument may be operated in a three-terminal or two-terminal mode. Other features include a test signal continuously adjustable from 4v down to 1 mv; an internal dc bias adjustable from —7 to 110v and drift capacitance of less than 0.001 pf in 24 hours.

Circle No. 176 on Subscriber Service Card

Strain Gage Transducer

A series of absolute pressure transducer units, capable of combustion chamber pressure measurements, is available from Atlantic Research Corp.

The series offers a choice of ranges from 0 to 500 through 0 to 10,000 psia (with over-range of 2x and burst pressure of 3x). Rated sensitivity is 2 to 4 mv/v, depending on the range. Other specifications include a combined linearity hysteresis of ±0.15%, temperature range of —100° to 300°F and bridge resistance of 350 ohms.

Circle No. 177 on Subscriber Service Card

Rocket Recorder

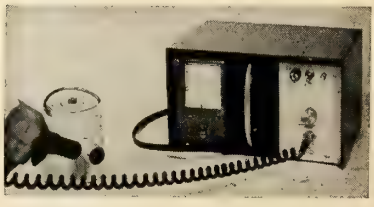
Raymond Engineering Laboratory is producing the Model 1849 rocket recorder, designed for accurate analysis of launch and re-entry vehicle performance.

The device stores and reproduces data with less than 1% RMS through wow and flutter. It has 200 g's sustained acceleration, 10 g's RMS and 30 to 2,000 cps vibration. The device can survive over 500 g's of shock for 1.5 ms duration. The recorder weighs 3 lbs. and measures 4 in. in diameter and is 4.5 in. long.

Circle No. 178 on Subscriber Service Card

Radiation Rate Meter

Gelman Instrument Co. is marketing an automatic recording radiation rate meter. The device records the level of radiation at every hour of the day for 31 days without changing the chart strip.



The meter features a halogen-quenched Geiger-Mueller tube to measure Gamma radiation. An end-window Geiger tube is available to detect Beta and Gamma radiation. It is available with chart speeds of 3, 15 or 30 in. per hour.

Circle No. 179 on Subscriber Service Card

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names in the news


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Charles E. Beck: Elected president, chief executive officer and a director and member of the executive committee of the American Bosch Arma Corp., Garden City, N.Y. He succeeds **Charles W. Perelle,** who was elected chairman of the board and will also serve as a consultant.

A. V. Zukas: Named president of the Aerospace Products Group of Parker-Hannifin Corp., Los Angeles. He succeeds **W. C. Loeman,** who is being transferred to Parker-Hannifin headquarters in Cleveland as group executive responsible for three major products divisions.

Don Fairchilds: Appointed director of public relations for Continental Motors Corp. and Continental Aviation & Engineering Corp. He was previously director of public relations for the Singer Co., Metric Div., Bridgeport, Conn.

Charles R. Sublett: Appointed chief of telemetry systems, Telemetrics, Inc., Santa Ana, Calif., a subsidiary of Technical Measurement Corp. He will be responsible for the design, development and application analysis of telemetry systems for special applications.

J. W. Martin: Named manager of Signature Support Engineering for the RCA Service Company's Missile Test Project at Patrick AFB, Fla.

Ludwig Roth: Appointed special technical assistant to the vice president-director of Douglas Space Systems Center, Santa Monica, Calif. He was formerly vice president and manager of research for Northrop Space Laboratories.

Edwin H. Matthewson: Named to the newly-created position of director of manufacturing and engineering at the Kaydon Engineering Corp., Milwaukee.

Hamilton O. Hauk: Appointed executive vice president of Infrared Industries, Inc., Santa Barbara, Calif. He was formerly with Raytheon Co., and is a retired Rear Admiral.

Milton L. Dunham: Appointed manager, technical service, Union Carbide Corp., Silicones Div., New York City. He has been with Union Carbide since 1945.

John C. New: Elected president of the Society for Experimental Stress Analysis for 1964-65. Head of the Test and Evaluation Division at NASA's Goddard Space Flight Center, Greenbelt, Md., he succeeds Prof. C. C. Perry of Wayne State University, Detroit.

C. L. Woodbridge and **Howard M. Levine:** Appointed technical vice presidents of HRB Singer, Inc., a subsidiary of the Singer Co., State College, Pa. Woodbridge will administer the company's technical efforts in the fields of infrared equipment and technique development, imagery interpresentation services and training, and rapid access technology. Levine will be responsible for the technical operations of the Opsearch Laboratory.

Microwave Electronics Corp., Palo Alto, Calif., has announced the promotions of **Arthur L. Webb** and **John Wurr.** Webb was promoted to vice president of manufacturing and Wurr to director of manufacturing.

Donald C. Webster: Joined Neville Instrument Co., Burbank, Calif., as vice president and chief engineer. He was formerly president of General Precision, Inc.

Wallace O. Fenn: To receive the Italian Academy's $40,000 Feltrinelli Prize in experimental medicine. He is director of the Space Science Center at the University of Rochester, Rochester, N.Y.

Robert J. O'Brien: Appointed director of the Engineering Division of Lockheed Propulsion Co., Redlands, Calif. He has been with Lockheed since 1963.

Allen H. Drayner: Named to the newly-created post of director of systems effectiveness for Martin Co., Friendship International Airport, Md.

Richard G. Woodbury and **Lawrence G. Lutz:** Appointed to newly created sales management posts in the J. W. Fecker Division of American Optical Co., Pittsburgh. Woodbury will manage the Eastern region and Lutz, the Western region.

Robert A. Charpie: Appointed director of technology for Union Carbide Corp., New York City. He has been with Union Carbide since 1950.

when and where

NOVEMBER

Sixteenth Annual MAECON Technical Meeting, Continental Hotel, Kansas City, Mo., Nov. 23-24.

Winter Annual Meeting of the American Society of Mechanical Engineers, Statler Hilton Hotel, New York City, Nov. 29-Dec. 4.

Joint Meeting of the American Nuclear Society and Atom Fair, Hilton and St. Francis Hotels, San Francisco, Nov. 30-Dec. 3.

DECEMBER

57th Annual Meeting of the American Institute of Chemical Engineers, Statler Hilton Hotel, Boston, Dec. 6-10.

Third Conference on Performance of High-Temperature Systems, Huntington-Sheraton Hotel, Pasadena, Calif., Dec. 7-9.

Third Annual Western Contamination Control Congress, sponsored by the Western Regional Chapter of the American Association for Contamination Control, Lafayette Hotel, Long Beach, Calif., Dec. 9-11.

Symposium on High-Energy Astronomy, sponsored by Air Force Office of Scientific Research, Atomic Energy Commission, NADA, National Science Foundation, Office of Naval Research, and the University of Texas, University of Texas, Austin, Dec. 15-18.

131st Annual Meeting, American Association for the Advancement of Science, Montreal, Canada, Dec. 26-31.

JANUARY

Eleventh National Symposium on Reliability and Quality Control, sponsored by the American Society for Quality Control and the Institute of Electrical and Electronics Engineers, Fountainebleau Hotel, Miami Beach, Jan. 12-14.

International Symposium on Solar Radiation, sponsored by the American Society for Testing and Materials, International Hotel, Los Angeles, Jan. 18-21.

Winter Meeting of the National Society of Professional Engineers, Jung Hotel, New Orleans, Jan. 20-23.

National Symposium on Hydrocarbon Analysis, sponsored by the American Society for Testing and Materials, Sheraton-Lincoln Hotel, Houston, Jan. 22-23.

Symposium on Fundamental Phenomena in the Material Sciences, sponsored by the Ilikon Corp., Sheraton Plaza Hotel, Boston, Jan. 25-26.

Joint Annual Meeting of the American Mathematical Society and the Mathematical Association of America, Univ. of Colorado, Denver, Jan. 25-30.

FEBRUARY

Reinforced Plastics Division Conference, sponsored by the Society of the Plastics Industry, Edgewater Beach Hotel, Chicago, Feb. 2-4.

Winter Convention on Military Electronics, sponsored by the Institute of Electrical and Electronics Engineers, Ambassador Hotel, Los Angeles, Feb. 3-5.

Unmanned Exploration of the Solar System, sponsored by the American Astronautical Society, the American Astronomical Society, American Geophysical Union, American Institute of Biological Sciences, Institute of Electrical and Electronics Engineers, and the American Institute of Aeronautics and Astronautics, Denver Hilton Hotel, Denver, Feb. 8-10.

Spring Meeting of the American Society for Testing and Materials, Statler-Hilton Hotel, Cleveland, Feb. 8-12.

1965 Electrical and Electronic Trade Show, sponsored by the Electrical Representatives Club and the Electronic Representatives Assn., Denver Auditorium Arena, Denver, Feb. 15-17.

MARCH

Symposium on High-Speed Testing, sponsored by Massachusetts Institute of Technology and Brooklyn Polytechnic Institute, Sheraton Plaza Hotel, Boston, March 8-9.

Aviation and Space Conference, sponsored by the American Society of Mechanical Engineers, Statler Hotel, Los Angeles, March 14-18.

International Convention of the Institute of Electrical and Electronics Engineers, New York Hilton Hotel and New York Coliseum, New York City, March 22-25.

Symposium on Thermophysical Properties, sponsored by the American Society of Mechanical Engineers, Purdue University, Lafayette, Ind., March 22-26.

Spring National Convention of the Society for Nondestructive Testing, Los Angeles, March 22-26.

Optical Society of America Meeting, Statler-Hilton Hotel, Dallas, March 31-April 2.

APRIL

International Symposium on Fission Product Release and Transport Under Accident Conditions, sponsored by the Oak Ridge National Laboratory, Oak Ridge, Tenn., April 5-7.

1965 Annual Region III Meeting of the Institute of Electrical and Electronics Engineers, Robert E. Lee Hotel, Winston-Salem, N.C., April 6-8.

1965 Annual Region VI Conference of the IEEE, Las Vegas, Nev., April 13-15.

15th Annual National Telemetering Conference, sponsored by the IEEE, ISA and AIAA, Shamrock-Hilton Hotel, Houston, April 13-15.

Symposium on System Theory, sponsored by Polytechnic Institute of Brooklyn, IEEE, Society for Industrial and Applied Mathematics, AFOSR, ONR, and the Army Research Office, New York City, April 20-22.

Southwestern Conference and Electronic Show, sponsored by the IEEE, Dallas Memorial Auditorium, Dallas, April 21-23.

Sixth Symposium on Engineering Aspects of Magnetohydrodynamics, sponsored by the University of Pittsburgh and the Carnegie Institute of Technology, University of Pittsburgh, Pittsburgh, April 21-23.

1965 London International Engineering Exhibition, sponsored by the London Chamber of Commerce, the British Mechanical Engineering Federation, and the British Electrical and Allied Manufacturers' Association, Olympia and Earls Court, London, April 21-30.

Annual Meeting of the Propulsion and Combustion Panel of the Advisory Group for Aeronautical Research and Development to the North Atlantic Treaty Organization (AGARD), "Advances in Chemical Rocket Propulsion," University of California, San Diego, April 22-25.

Western States Spring Meeting of the Combustion Institute, Los Angeles, April 26-27.

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The High Price of Silence

EXPENSE ACCOUNTS once again are being used as the brush with which to tar this industry as an evil, corrupting force in the nation. We now are confronted by the news that the General Accounting Office has been browbeating industry firms into providing the names of military and NASA officials entertained on company expense accounts.

Those officers named then have been subjected by GAO to what has been described as an FBI-type grilling about their relationships with the firms involved.

This whole sickening affair with its police-state tactics is one further step away from the democracy which this industry and the military presumably are pledged to defend.

It seems almost part of a deliberate plot to dismantle what has been a very effective partnership in the past. The thought that industry officials as a regular business practice ply their gullible government counterparts with daily luncheon martinis in order to obtain contracts is a ridiculous one.

It is far past time a few people in industry and government stood up to say so.

We understand the GAO investigation into expense accounts is intended to provide an investigating subcommittee of the House Armed Services Committee with ammunition for further attacks on the industry. It began last spring when GAO investigators demanded that several aerospace firms provide the names of government personnel entertained at company expense.

In at least one instance, company management debated all summer whether to compromise military friends in what was sure to be a vicious investigation. The threat of subpoena, with its accompanying implication in court that the company had something to hide, brought a collapse of management resistance.

Within 48 hours of obtaining the names, GAO investigators turned up at military and NASA installations to grill those on the lists. The victims are both angry at the companies for providing the names and apprehensive over the ugly distortions which could come out of a headline-hunting committee.

We also are told that this was one of the reasons behind the Dept. of Defense amendment of its standards of conduct directive—the hope that the "no free lunch" edict would prove its innocence in advance of the charges.

The dirty tactics used by GAO to obtain information to which its right is questionable are disgusting. But equally nauseating is the lack of moral courage right down the line in industry and government.

Where is the man with the guts to stand up and say that a business luncheon is an accepted practice in this country and that there's not a single moral thing wrong with it? Where has the Aerospace Industries Assn. been through all of this? When Secretary McNamara issued his insulting new conduct code, the military associations were quick to reply. But where was AIA in defense of its industry? Where has it been while GAO has been browbeating its members? Is AIA afraid to stand up and admit that its member firms on occasion take people to lunch or dinner on the expense account? The press several times has asked AIA for its position on the new McNamara directive. The association has declined to state it. AIA has failed the firms which support it.

And just what sort of courage has the Pentagon shown? Confronted by the pending Congressional investigation of expense accounts, the Dept. of Defense threw overboard in panic a sensible and workable code of conduct. In its place has been substituted something so insulting and ridiculous that Congress has to regard it as an admission of guilt. Rep. Porter Hardy, at the head of the subcommittee, must surely ask: "If something wasn't rotten, why was this needed?"

Was there not someone in the Pentagon willing to declare his trust that the military could not be corrupted by a free lunch or a tie-clasp? Was there no one to point out that the reason industry representatives paid for the meals more often than the military officers was that the military has no expense accounts to cover this? Was there no one to suggest that considerable business of benefit to the government was conducted over luncheon tables? Apparently not. Confronted by opposition, the Pentagon troops broke and ran like rabbits.

And what of the companies which turned over the names? Where was their courage on behalf of their friends in the military? Rather than risk their company image, they preferred to surrender. We hope the picture of a GAO investigator shaking his finger under the nose of a general officer and demanding to know what he talked about at that business luncheon haunts them forever. We know what the reaction of some of the officers has been—and it hasn't done much for the company image.

WE SUGGEST THAT if the companies approached all had had the courage to refuse the GAO, it would have ended there. Is it so hard to say, "We don't believe you should have the names, not because we have something to hide, but because this is conventional business practice and you have no right to them. We are not guilty of anything and we are willing to say so in court."

Apparently courage is in short supply these days.

Certainly, there have been some questionable practices. The Dept. of Defense could and should have forthrightly dealt with the offenders under the standards of conduct directive as it stood. Instead, a course was chosen which is certain to be judged as self-condemnation.

We are not proud of either the industry or the government in this matter. Continuing acceptance of the insinuations and accusations can only weaken the partnership whose health is so vital to our national security. It is time someone of stature in the industry showed the common sense and guts to stand up and say so.

William J. Coughlin

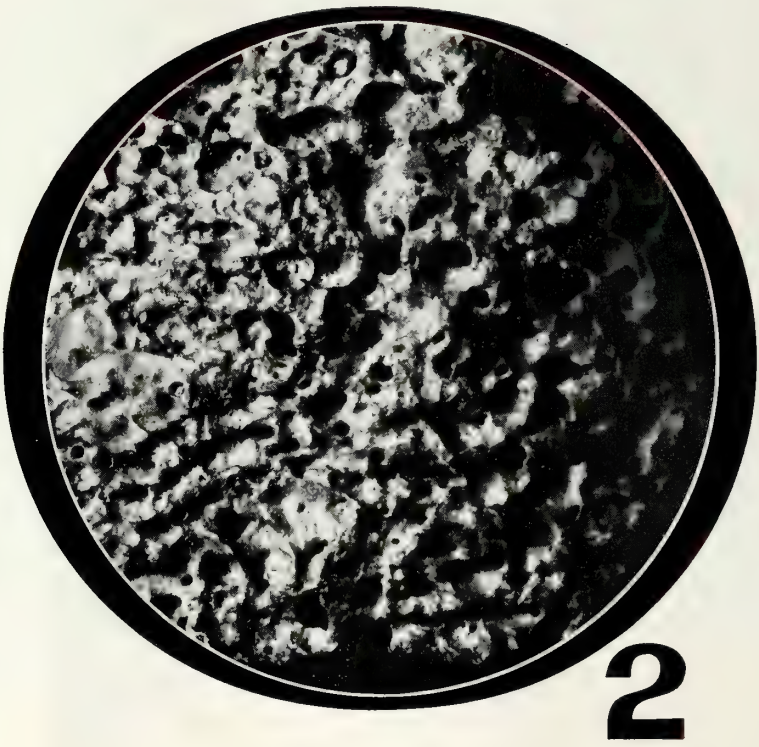


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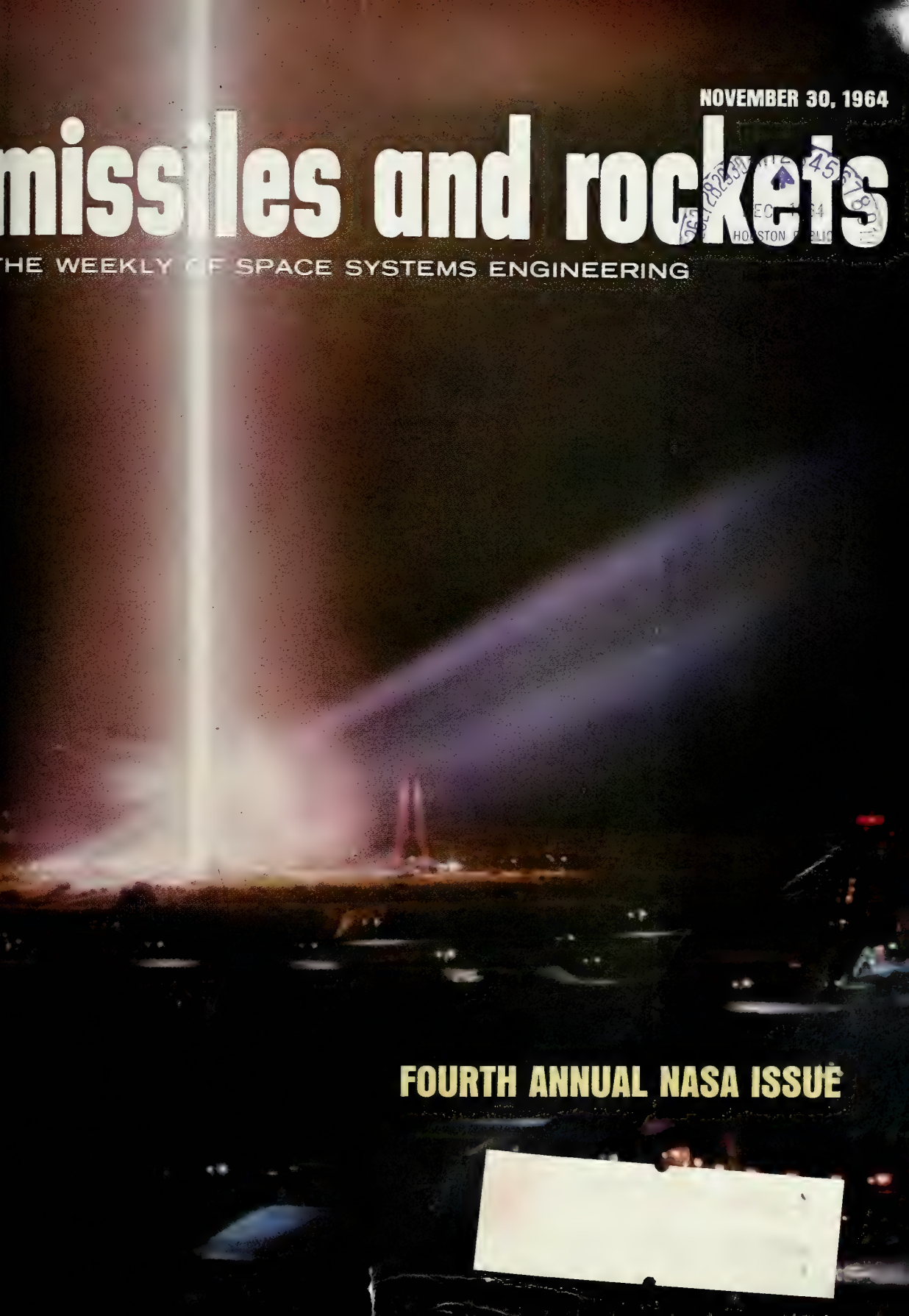
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THE WEEKLY OF SPACE SYSTEMS ENGINEERING

HOUSTON PUBLIC



FOURTH ANNUAL NASA ISSUE





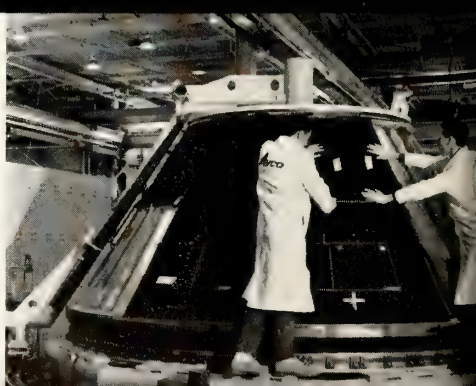
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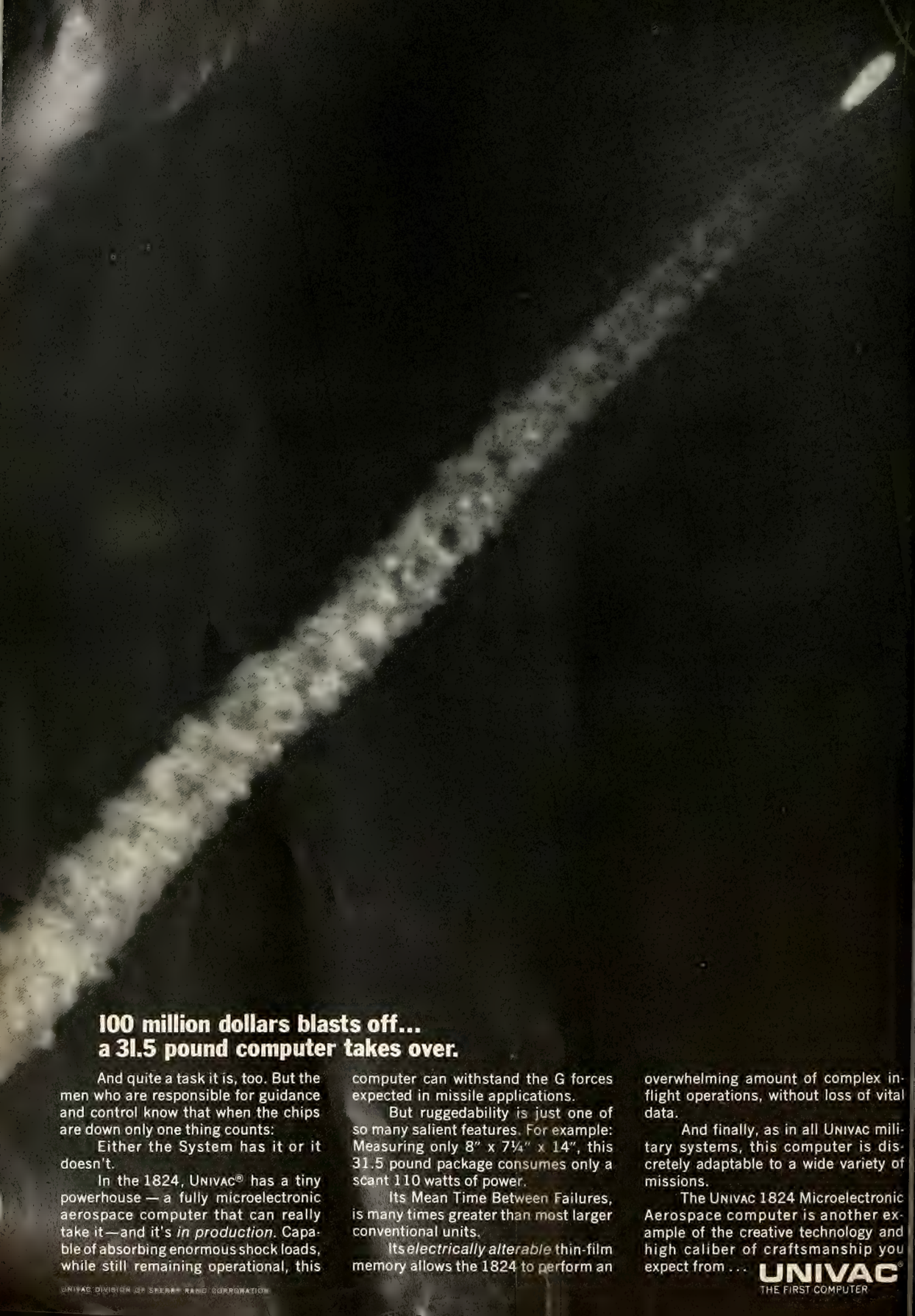
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Published each Monday with the exception of the last Monday in December by American Aviation Publications, Inc., 1001 Vermont Ave., N.W., Washington, D.C. 20005. Cable Address: AMERAV.

Printed at Judd & Detweiler, Inc., Washington, D.C. Second class postage paid at Washington, D.C.

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Subscription rates: U.S. and Possessions, Canada, and Pan American Postal Union Nations: 1 year, $5.00, 2 years $8.00, 3 years $10.00. All other foreign: 1 year $15.00, 2 years $25.00, 3 years $35.00. Air freight to Europe: 1 year $20.00, 2 years $30.00, 3 years $40.00. Single copy prices: regular issues 50 cents each; special issues $1.00 each. Subscriptions are solicited only from persons with identifiable commercial or professional interests in the missile/space industry. Subscription orders and changes of address should be referred to Circulation Fulfillment Mgr., Missiles and Rockets, 1001 Vermont Ave., N.W., Washington, D.C. 20005. Allow 4 weeks for change to become effective and enclose recent address label if possible.

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THE COVER



NASA's Orbiting Geophysical Observatory (OGO) satellite, built by TRW Space Technology Laboratories, is launched for first time Sept. 4 from Cape Kennedy atop an Atlas-Agena B booster. M/R's Fourth Annual NASA Issue—devoted to the Space Program beyond Apollo—starts on p. 37.

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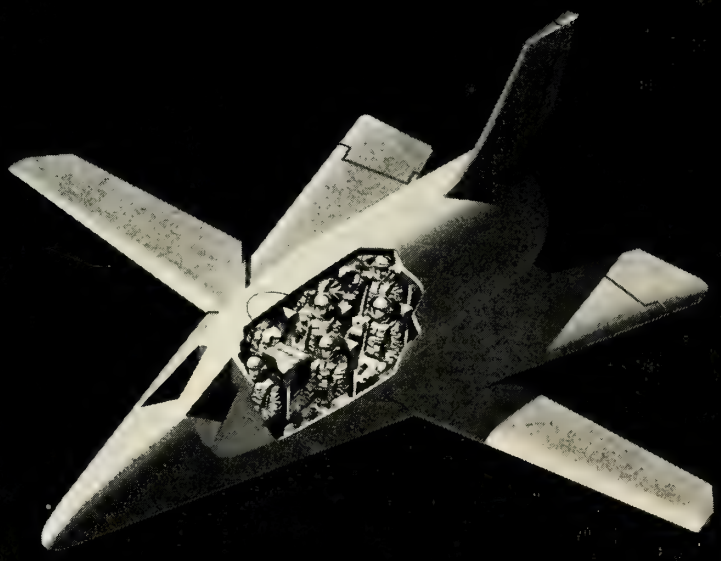
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How to be at home in orbit

What Boeing is doin



bout MANNED SPACE FLIGHT:



Life Support System

Five men recently completed a 30-day NASA space mission—without leaving the ground. A Boeing space chamber (above) simulated long-term space flight conditions. The mission tested water reclaiming and waste disposal systems as well as a method of supplying oxygen with sodium superoxide chemicals. Tests like these help in designing future spacecraft (such as the 12-man variable-wing vehicle concept at left).

Meteoroid Studies

During space travel, vehicles may encounter meteoroids large enough to create a hazard. To measure the danger and to devise a spacecraft protective system for astronauts, Boeing is conducting research for NASA. Using a Boeing-developed gas "gun," researchers shoot pellets at approximately meteoroid speeds (21,000 mph) to test various types and combinations of protective plating for spacecraft.





Vehicle Design

To assist the Air Force and NASA in development of criteria for manned orbital laboratories, Boeing has conducted studies of vehicles utilizing from 2- to 12-man crews. Studies include booster-vehicle integration, life support, micrometeoroid protection and logistics involving crew rotation and resupply.

Rendezvous in Space

In simulated flights, Boeing is investigating techniques for bringing two orbiting vehicles together in docking missions. The "pilot" sights his target vehicle on a projected TV presentation, and using controls operating through a computer, maneuvers his vehicle through a complete docking run.



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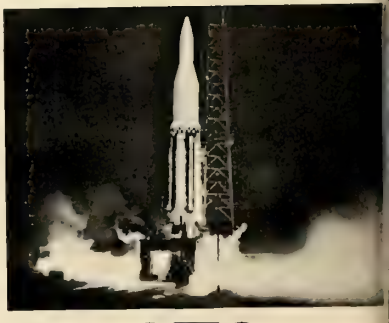
The reluctance of the others to make any promises was quite understandable. The assignment called for the modification and production of 400 miniature d-c amplifiers for a very special application. And these amplifiers had to be in the customer's hands within 130 days.

Our engineers knew they had a tough schedule ahead of them. However, because of CEC's leadership in the transducer field, they also knew they had the facilities to do the job.

100 days later, the customer received the 400 amplifiers—a full *30 days ahead of schedule.* But what was equally important, these instruments were so well designed and constructed there wasn't a single rejection in the lot.

This is a significant case-in-point why CEC's reputation for quality and capability is now unchallenged in the rapidly growing areas of data recording.

It also explains why CEC maintains a network of 22 sales and service offices throughout the nation. To expedite application engineering. To familiarize customer personnel with new instrumentation. To make certain that every product meets or exceeds the most demanding specifications.

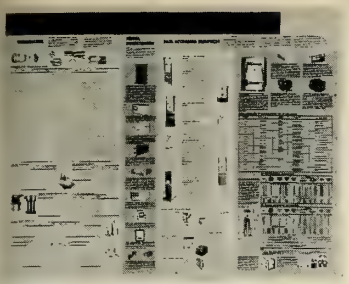


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Signal Conditioners
Chart shows 11 basic types and where they may be required.





Magnetic Tape
Chart shows 8 analog and digital recorder/reproducers with support equipment.

Direct Readout
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letters

Pro-McNamara Cudgel

To the Editor:

Your Nov. 19 editorial ("The Aftermath") has again taken up the cudgel against Secretary of Defense McNamara. It is evident that you are well versed in the art of assassination by innuendo. Your dislike of McNamara must be personal, not professional. You insist on implying that his incompetence is proven by a) failing to register to vote, b) Bay of Pigs, c) Gulf of Tonkin "snafu," d) Bien Hoa fiasco, and e) statement that anti-missile missile could save 25% of U.S. population. Only five actions out of four years of daily decisions. Not a bad record even if increased an order of magnitude. Definitely not a record to be ashamed of or be condemned for.

As a Secretary of Defense I have heard nothing but admiration for him in the military and industry, grudging though it may be at times. Such innovations as Program Definition prior to any program approval, closing of pork-barrel installations and cancelling of useless programs has been a healthy purge for the Defense Department.

He has not been 100% right in his decisions or actions, but then I do not know of one human being on Earth who has, or ever will be so endowed, including you. Personally, a little less bias and a lot more judgment, tempered with a smidgeon of your own intelligence and belief in your readers' discernment would appease my impatience with your grossly obvious vendetta to "Get Rid of McNamara."

George Sirbola
Apalachian, N.Y.

Drawing the Line

To the Editor:

Your Oct. 12 editorial states that the ethics of business relationships involving government employees must be determined by the individuals involved. Industry has long discarded that idea by defining the ethics to be used by its own buying groups.

If we can delude ourselves that gifts, lunches, drinks, etc., are tendered primarily for friendship's sake then we must explain why the friendship is shown by the "sellers" rather than the "buyers" 99% of the time.

Your own bewilderment at whether to draw the line at one lunch or 100 lunches makes it clear that McNamara is correct in drawing the line at *no* lunches.

The custom of giving lunches and gifts has reached the same impasse that giving stamps at supermarkets has reached. Competitors have practically cancelled each other out and have only succeeded in raising the cost of doing business. This, of course, is only a minor aspect of the problem and, anyway, the two cases are not truly analogous since the acceptor of stamps is buying with his own money while the acceptor of lunches is not.

If you will investigate the feelings of those who are tyros in the buying business you will find that they invariably feel "odd" in accepting lunches or gifts. In this case their instincts are correct and it is the old-timers in the business who have conditioned themselves to accept the situation as normal.

This is a case where a black-and-white decision can almost always be made, and McNamara did the right thing in specifying clearly the correct decision to be made.

S. R. Mayerhofer
Waimea, Kauai, Hawaii

Get Out and Get Under

To the Editor:

Reliable sources have informed this writer that a new system now in the planning stage will revolutionize the transportation system. A defense-research team, recently removed from the defense effort, developed the "Hermes," a transistorized, miniaturized propulsion system, which will prove highly effective in the field of mass transport.

As a direct result, a phase-out of certain automobile companies is being considered. It is generally felt that nothing really new and constructive has been produced by these companies, and phasing them out over a period of years will not in any way affect the efficiency and/or effectiveness of the transportation system.

People now working for the industry will be reassigned to other jobs within limits of their ability, and the head of one of the largest automobile companies, a brilliant computer named MAC, will produce the Hermes instead.

The military have expressed marked interest, and it is felt that the defense-research team may be reassigned to defense work after the necessary budgetary adjustments have been made.

Tony Berger
Burbank, Calif.

ASTROLOG REPRINTS

REPRINTS of the latest edition of the MISSILES AND ROCKETS *Astrolog, which appeared in the Nov. 9 issue, may be obtained from:*

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Missiles and Rockets
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$28,500

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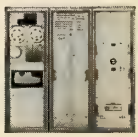
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DDP-24A/$69,000

Same mainframe features as DDP-24 with modified I/O package.



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The Countdown

WASHINGTON

ICBM-X To Be Proposed by BSD

A quantity buy of the advanced intercontinental ballistic missile known as ICBM-X is anticipated if Dept. of Defense approves plans to be submitted by Ballistic Systems Division to Air Force headquarters early next year. Studies indicate the missile will be similar to an advanced *Minuteman,* but no decision has been made to limit it to solid propulsion. Deployment would begin in the mid-1970's. ICBM-X probably would be designed to use existing *Minuteman* facilities, but would be considerably more accurate and carry a more diverse payload.

Red China May Have Delivery System

Speculation on how long it will take Red China to develop a delivery system for its new atomic bomb seems to have overlooked the fact it already has one such system. It was reported several years ago (M/R, Oct. 10, 1960, p. 15) that Red China possessed a number of Zulu-class submarines modified to launch two Soviet-designed missiles. These were designated as *T-10* and were said to be capable of carrying nuclear warheads.

Pegasus To Decide Saturn Date

Launch date for the next *Saturn* booster will be determined by an important environmental test of the *Pegasus* satellite early next month. The launch, initially set for the last quarter of this year, was delayed by engineering problems in the satellite. It now is scheduled for the first quarter of next year. The environmental test will determine the exact date.

Apollo Abort Test Set at White Sands

Maximum "Q" abort test of the *Apollo* spacecraft launch system is scheduled for White Sands Missile Range no earlier than Dec. 8. Launch by the *Little Joe II* booster also will test the protective cover for the Command Module, as well as canards used to turn the spacecraft.

MSFC Seeks New Satellite Approval

Marshall Space Flight Center is pushing for approval of a *Cislunar Meteoroid Detection Satellite* as payload for the projected *Saturn 1B/Centaur* launch vehicle. Martin Co. is studying the satellite under a $200,000 contract with Langley Research Center.

Air Force To Fund Missile Studies

Air Force has asked for bids on a highly classified study to define an advanced higher-performance small missile propulsion system. It also is seeking proposals for a classified study of deception-basing concepts for ballistic missiles. Both are under the direction of Ballistic Systems Division.

Wasp Moves into Advanced Development

Army Missile Command is funding an advanced development program for *Wasp,* a 40-mm anti-personnel air-to-surface rocket for helicopters and aircraft. Emerson Electric Co. developed the lightweight, spin-stabilized rocket as an in-house project before winning initial funding from AMC.

Nike-X Tooling Decision Near

Sec. McNamara must approve funds for at least some pre-production tooling for *Nike-X* if he plans to hold to a schedule of deployment of the first battery in 1969-70. Unless this money is included in the '66 budget, it would be impossible to meet this date. Pre-production tooling money has always been the bellwether for *Nike-Zeus/X*. In the latter 1950's and 1960, the Army pressed hard for at least initial funds and at least once it won its case only to have the money go unspent when winds shifted in the Pentagon.

Polaris Investment Now Totals $11 Billion

U.S. investment in *Polaris* totals $11 billion through FY 1965. The 41st submarine, the last in the *Polaris* program, will be ready for sea in December, 1966. Defense officials usually claim that the 41-boat fleet will be operational by the end of FY '67.

INDUSTRY

California Asks for Transportation Bids

Gov. Edmund G. Brown has asked California aerospace companies to submit bids on a study to suggest the kind of air, sea and land transportation system the state should have in 30-50 years. The request is one of four in a state effort to utilize system development talents of the industry in solving social problems. The governor set a 30-day deadline for submission of bids and said any to cost more than $100,000 would be unacceptable. Other bids were asked in the fields of data planning, mental illness and criminal illness.

Thornton Sees Bright Future for Industry

Litton board chairman Charles B. Thornton says he is not at all gloomy about the future of the defense industry. For one thing, he predicts, overseas markets are just beginning to open up. Thornton, incidentally, has been mentioned as a possible successor to Robert McNamara if the Secretary of Defense should leave the Pentagon.

Atlantic Research Corp. on the Block?

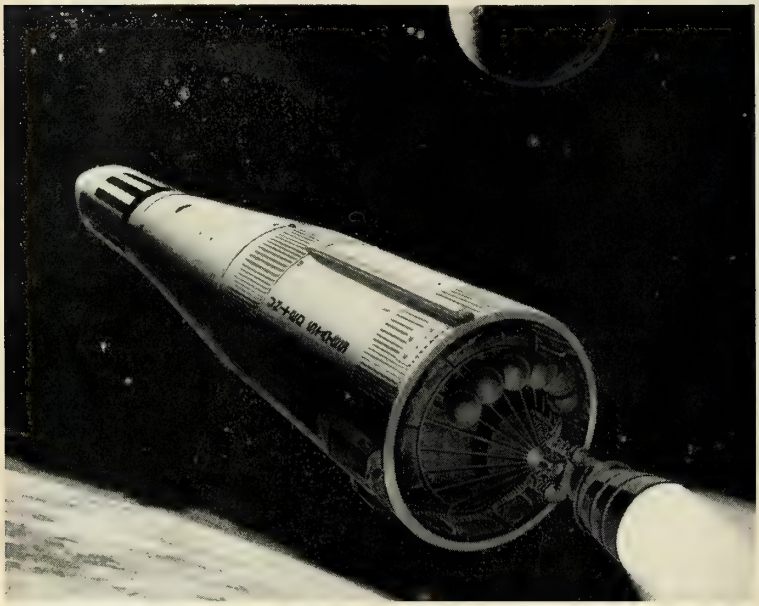
Possible merger or sale of Atlantic Research Corp. has been discussed with Lockheed Aircraft Corp. and other major industry firms. Clearing up of ARC's difficulties with the Securities & Exchange Commission undoubtedly would have to precede any such move. It is known that several major ARC stockholders would not be averse to an offer.

INTERNATIONAL

Soviets Indicate Big Space Program

Soviet space scientists attending the space medicine symposium at San Antonio, Tex., left little doubt in the minds of those who talked with them that the Soviet Union is undertaking a major space effort. They talked freely of problems expected on Mars, Jupiter and the Moon.

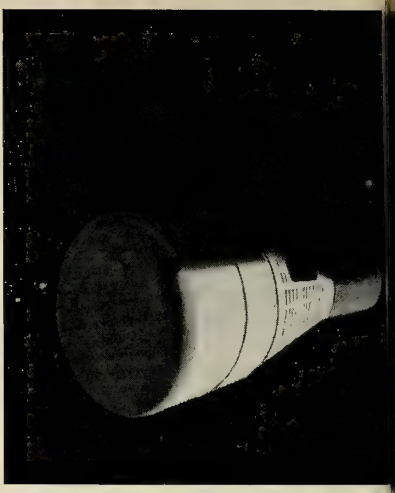
LOOK WHAT DOUGLAS IS DOING NOW!



TO HELP PUT MAN ON THE MOON, *Saturn* S-IVB is being built by Douglas under direction of NASA's Marshall Space Flight Center. S-IVB is 58 feet tall and 22 feet in diameter. As upper stage of *Saturn*, it will provide the thrust that will send 3 *Apollo* astronauts from earth orbit to moon orbit.

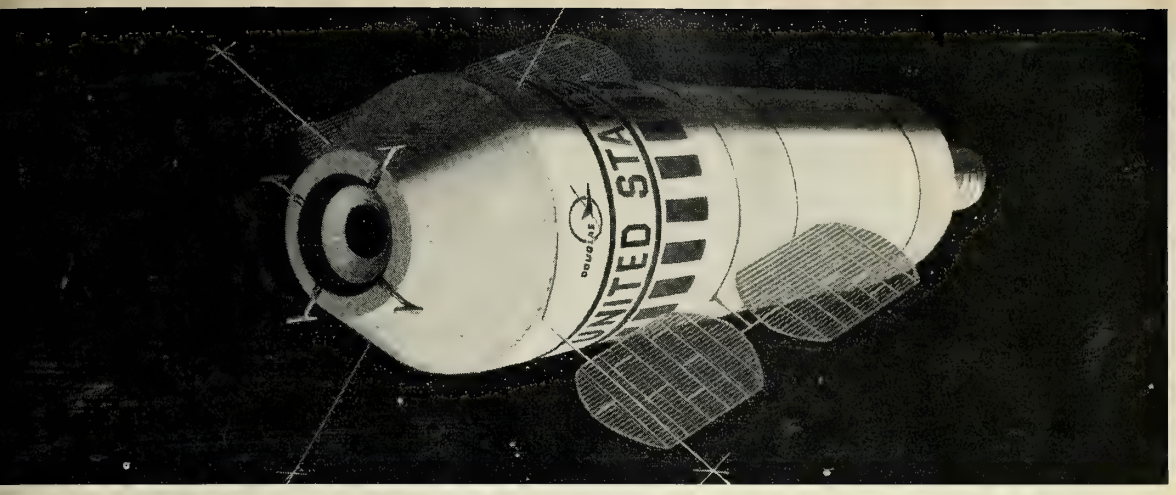


PACKAGING THE EARTH'S ENVIRONMENT for delivery anywhere in the solar system is the aim of Douglas biotechnology research. Means are being developed to provide spacemen with every factor they require to allow them to survive and perform efficiently during protracted space missions.

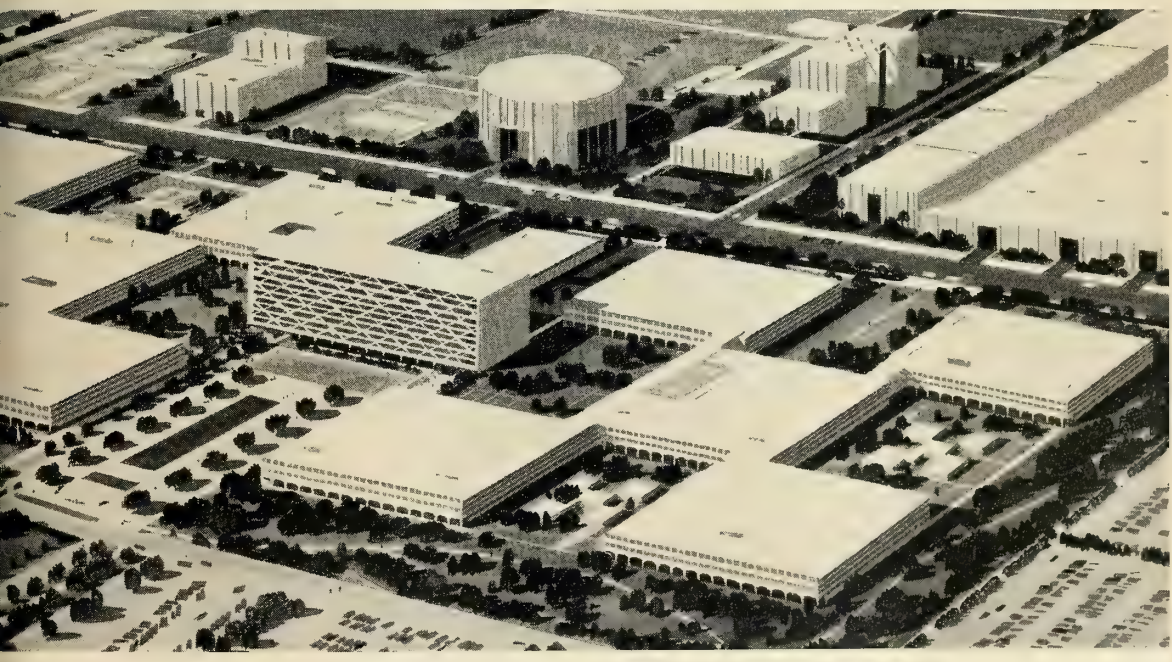




MORE BOOST FOR DELTA, world's most reliable space vehicle, is being achieved for the National Aeronautics and Space Administration by utilizing the Air Force/Douglas Improved THOR as first stage. Douglas is developing the thrust-augmented *Delta* (TAD) for NASA's Goddard Space Flight Center. NASA will continue use of the standard Douglas *Delta*.



O STUDY SPACE FROM UP THERE, NASA has ssigned studies of advanced planning for a six man orbiting pace laboratory to Douglas. It could be boosted into orbit y *Saturn* sometime in the '70s. Crewmen, supplies and equipment would be ferried to and from it in *Gemini* capsules. Advantages to be gained from the space laboratory are enormous in such varied fields as weather prediction, medicine, bacteriology, astronomy and many others.



HE NEW DOUGLAS SPACE SYSTEMS CENTER n Huntington Beach, California, is one of the world's finest rivately-owned space complexes. Here, talented engineers, cientists and technicians of the company's Missile & Space ystems Division are supported by advanced facilities as they research, test and build systems and vehicles that will help maintain U.S. leadership in space exploration. The new Douglas Center is designed for continued growth. Its capacity will be enlarged to meet the requirements of even more formidable space challenges of the future.

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To achieve the required velocity measurement accuracy of 1 ft/sec at 35,000 ft/sec in the injection firing window, increased range tracking capability across the width of the launch corridor is required. One solution, now in the planning stage, is to slave two advanced instrumentation ships to an island-based station in a triangular configuration, maintaining minimum separation of 250-500 nm.

Complex problems in telemetry, navigation, tracking, communications, and data handling must be solved. Of paramount consideration are:

☐ systems to maintain precise time synchronization among stations and Central Control. ☐ systems to measure ship vertical and heading within 30 seconds of arc. ☐ systems to measure range and range rate to the required accuracy. ☐ systems to provide near real-time data handling and transmission among ship/land stations for rapid trajectory-correction information.

On this and other programs, assignments are immediately available to senior electronic engineers with *systems and planning* background in: pulse and CW radar/telemetry/optics/infrared/data handling/communications/closed circuit TV/frequency analysis/command control/underwater sound/timing/shipboard instrumentation.

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Gemini, Centaur Shots Due This Week

Two important steps in the U.S. space program—the launches of *Gemini/Titan II* and *Centaur 4*—are scheduled from Cape Kennedy this week.

GT-2 will be an all systems suborbital flight down the Atlantic missile range slated for no earlier than Dec. 7. Primary objectives of the flight are an all-systems test of the spacecraft subsystems and the gathering of re-entry heating measurements to provide data for future manned orbital flights.

The *Atlas-Centaur 4* flight is scheduled to go no earlier than Dec. 4. The flight profile calls for three important firsts in the liquid hydrogen upper stage's research and development program.

It will be the first time for the vehicle to be steered by its inertial guidance system, the first time it will carry a mass model of the 2,100-lb. *Surveyor* spacecraft that *Centaur* will boost toward the Moon in late 1965 or early 1966, and it will be the first time that the *Centaur* engines will have been shut down and restarted in space.

During the *Gemini* launch, the *Titan II* booster will boost the 7,000-lb. spacecraft to an altitude of 105 miles, then arch it over and plunge it toward the Atlantic Ocean at a speed of 16,600 mph. This is far greater than the nominal re-entry speed expected during orbital flights.

The flight will last about 20 minutes. Plans call for the spacecraft to be recovered at its impact point 2,150 miles down range from Cape Kennedy. If all goes well, the impact site will be 800 miles east of San Juan, Puerto Rico.

The results of *GT-2* will have an important bearing on the first manned orbital flight in the two-man space flight series now scheduled for next spring. If technical problems develop during *GT-2*, the likelihood is that *GT-3* will be delayed.

Secondary objectives of the *Centaur* flight are to:

—Obtain data on performance of *Centaur's* main engine system;

—Test *Centaur's* capability to perform a retromaneuver;

—Obtain data on vehicle acceleration;

—Obtain information on propellant behavior and heat transfer;

—Demonstrate the capability of the small rocket motors (ullage rockets) on the *Centaur* to position the fuel for proper engine restart and burn while the vehicle is in a state of weightlessness.

The *Atlas* booster will lift *Centaur* to an altitude of 72 miles. After jettisoning the *Atlas* first stage and the insulation panels, the *Centaur* engines are ignited at an altitude of 75 miles, injecting the upper stage into a 100-mile parking orbit.

After the engines are shut down, *Centaur* and its *Surveyor* payload will coast for about 25 minutes. Its engines will then be restarted to inject both into an elliptical orbit of 5,700 miles apogee and 100 miles perigee. The orbital period will be 192 minutes.

Centaur and its dummy payload will weigh some 6,500 lbs. in orbit.

Immediately after second burn, the *Centaur* will be turned around in



Firing Tests Titan III-C Flight Instrumentation

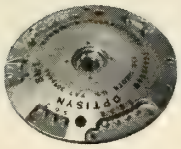
FIRST TEST of Titan III-C flight instrumentation system was coupled to this static firing of the 120-in. solid booster at United Technology Center, Coyote, Calif. More than 300 types of data were collected during the two-minute firing. Two of these million-pound-thrust units will boost the Titan III-C in flight tests beginning next year at Cape Kennedy. The vehicle is slated to launch payloads including the Air Force Manned Orbiting Laboratory and communication satellites.

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WE'VE GROWN SMALLER

AND SMALLER AND

SMALLER



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By 1962 it had shrunk to 2½″,

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preparation for a retromaneuver. This is designed to move the upper stage away from the *Surveyor* spacecraft, although in the *AC-4* test actual separation will not occur.

Liquid hydrogen and oxygen, however, will be blown through *Centaur*'s engines providing sufficient thrust to effect a change in velocity.

Centaur contains an all-inertial guidance system that will be flown "closed loop" for the first time on *AC-4*. On previous missions, the guidance system was functioning for evaluation purposes but was not in control of the vehicle.

The guidance system, developed for NASA by Honeywell, Inc., consists of an inertial platform, digital computer and associated electronics.

After liftoff, vehicle velocity and position and vehicle guidance commands will be continuously computed by the inertial system for the vehicle's autopilot, which will execute control functions such as engine gimballing, cutoff and restart.

The 2,100-lb. *Surveyor* mass model is representative of the operational spacecraft in weight and location of center of gravity. It also is shaped to dynamically simulate *Surveyor's* fundamental modes and frequencies of vibration.

The model consists of ballast simulating the *Surveyor* retro-rocket and solar cell panel/high-gain mast assemblies. No electrical or electronic equipment is contained on the model, with the exception of environmental sensors, associated cabling and *Centaur*/mass model interface electrical connectors.

Deep Sea Program Started

A $200-million Navy program for Development and exploitation of deep submergence vehicles is under way within the Special Projects Office of the Navy.

Reprogramming of $3.5 million has allowed the Navy to start this program in FY '65, rather than waiting for the new budget. This reflects the importance that the Navy and the Defense Dept. attach to the new program.

Funding, while substantial, is about $130 million below that recommended by the Deep Submergence Systems Group (DSSG), headed by Rear Adm. E. C. Stephan, USN (Ret.). This group had studied the Navy plan and capability for location, identification, rescue from and recovery of deeply submerged objects from the ocean floor and was responsible for recommending a five-year program to top Navy officials.

The DSSG grew out of the April

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The world's most powerful vibration testing system operates within 4.9 miles of the nearest gantry of the George C. Marshall Space Flight Center. So does the acoustical generator that has produced one of the loudest sustained noises ever created by man. And now the fastest and most complete data processing installation specifically designed for analyzing and correlating vibration and acoustic environmental test data. They are all part of the 125-acre Huntsville, Alabama, facility of Wyle Laboratories, situated just across the road from the Army Missile Command's Redstone Arsenal, to provide the aerospace industry with on-the-job capabilities for major engineering, testing, research and analysis. The wide range of equipment and services available covers the testing of components and systems in Induced Environments, Natural Environments, Functional Testing, and Combined Environment Testing, and Support Services including chemical cleaning, instrumentation, and instrument calibration. Huntsville capabilities backed up by Wyle California installations comprise the world's largest aerospace testing company.

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Microdot Model 412 FM Signal Generator achieves frequency accuracy of 0.0003% and better stability than other instruments of comparable size through a crystal-controlled time base generator.

In addition, many convenience features make the 412 the easiest-to-use, most practical unit available. Single-knob frequency control permits fast frequency search. Lighted push buttons virtually eliminate human error. Illuminated digital frequency display enables instantaneous interpretation of output. The compact and relatively lightweight 412 is ideal for command receiver checkout and a variety of applications in aircraft, on shipboard, in missiles and spacecraft, and in logistic electronic repair.



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10, 1963, Thresher disaster and the Navy's inability to cope with the problem of finding it.

The primary difference between the Chief of Naval Operations requirements in deep submergence and the DSSG's recommendations is in the number of vehicles to be built. Both programs cover five areas: submarine location escape and rescue systems; large object salvage systems; deep ocean research, investigation and small object recovery; man in the sea, and supporting research.

RFP's are expected to be issued to industry in the spring and early summer of 1965 for various subsystems to fulfill deep submergence needs. If Special Projects can obtain a waiver from DDR&E for program definition, a contract could be issued by fall of 1965.

SP officials feel that the unique character of the program might win a PDP dispensation. If it does not, development contracts would be delayed for a minimum of eight months. Separate contracts are expected to be issued for the major sub-systems—such as the pressure capsule, the sensor suit, the free-flood vehicle and the integration, control and internal systems—with SP acting as its own systems contractor. This is in keeping with the project's method of doing business on the *Polaris* program.

The major problem foreseen in the deep submergence program, and one that is expected to be limiting in all its efforts, is that of developing, fabricating and using materials. Prime candidates at the moment are high-yield-strength (150,000 psi) steels and 120,000-psi titanium. Fiber-reinforced plastics of 200,000-psi yields and massive glass at 300,000 psi are also possibilities.

Westinghouse Awarded 487L

Final winner of the Air Force's 487L Survivable Communications System appears to be Westinghouse Electric Corp. In the second (cost) phase competition with Space-General Corp., Westinghouse bid $30.3 million as compared with $36.2 million for system development.

Now subject to review and probable further negotiation by the Air Force Electronic Systems Div., the contract will involve development of several semi-hardened transmitter stations employing 1,200-ft.-high towers, a large number of hardened receiver sites, and airborne command-post stations. Operating at very-low and low frequencies, ground-to-ground, ground-to-air and air-to-ground telecommunications circuits will be required.

The system will be designed to handle command and control data between the Joint Chiefs of Staff, the Commander of the Strategic Air Command and the SAC forces.

Other bidders in the earlier Phase 1 (technical) competition included IT&T Corp., Sanders Associates, Inc., TMC Corp., Ling-Temco-Vought, Inc., Collins Radio Co., Page Communications Engineers, Inc., and Radio Corp. of America.

Old ICBM Phase-Out Due

First generation U.S. ICBM's will be completely phased out by July, 1965, with the less vulnerable, faster-reacting and more accurate *Minuteman* and *Polaris* missiles almost completely assuming the role of U.S. strategic deterrent.

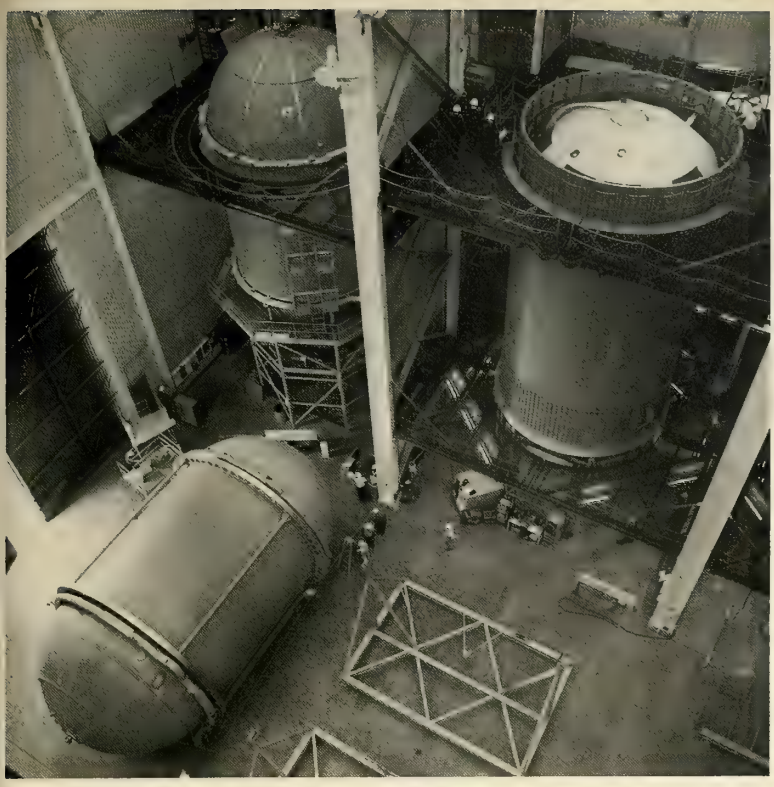
All 54 of the "generation-and-a-half" *Titan II* storable fuel ICBM's will be retained, however. This was revealed in Defense Secretary Robert S. McNamara's latest rash of base closings, which is eventually expected to add $477 million a year in savings in operating costs to the already better than one-half million dollars saved in previous base closings.

It has not yet been disclosed whether the *Atlas* and *Titan* missiles being phased out will be converted to space boosters, as was done in the case of *Thor* missiles brought back from England. However, General Dynamics has run studies for the Air Force on this subject, with the conclusion that modifications to the *Atlases* can be made, although the cost advantages are in some question.

Titan II is being retained primarily because of its large payload capability. With the exception of manned aircraft, this missile can carry the largest nuclear weapon available in the U.S. It is estimated that the *Titan II* warhead has a yield of between 15 and 20 megatons.

The announcement that the *Atlas* and *Titan I* missiles would be phased out was somewhat surprising. The FY '65 budget originally called for retirement of only 29 of the earliest *Atlases*, mostly *D* versions. The plan originally was to phase out these soft, relatively unreliable and cumbersome missiles from the inventory over the next several years. However, the pressure to get a dollar's worth of defense for every dollar spent appears to have accelerated the schedule.

Asked if the *Atlas* and *Titan* retirement represented a step in arms reduction, McNamara replied "there is absolutely no connection between arms reduction and these closures.



Douglas Saturn Stage Production Humming

THREE S-IVB stages, the top stage of the Saturn V launch vehicle, are shown in various stages of completion at Douglas Aircraft Co.'s Space Systems Center, Huntington Beach, Calif. The S-IVB stage is 60 ft. long and 22 ft. in diameter. At right, newly completed dynamics test stage is in final checkout. In adjacent tower, another stage undergoes cleaning and degreasing before checkout. Vehicle in horizontal position is being readied for placement in hydrostatic tank for pressure tests.

In fact, they leave us better prepared to carry out our defense and civilian needs."

This is the schedule for inactivation of these missiles:

—*Titan I* missile bases—By April, 1965, squadrons at Beale, AFB, Calif.; Ellsworth AFB, S.D.; and Larson AFB, Wash. By July, 1965, two *Titan I* squadrons at Lowry AFB, Colo., and one at Mountain Home AFB, Idaho.

—*Atlas E's*—By April, 1965, squadrons at Forbes AFB, Kan., and Francis E. Warren AFB, Wyo. By July, squadron at Fairchild AFB, Wash.

—*Atlas F's*—By April, 1965, squadrons at Walker AFB, N.M.; Altus AFB, Okla.; and Dyess AFB, Tex. By July, 1965, those at Schilling AFB, Kan.; Lincoln AFB, Neb.; and Plattsburg AFB, N.Y.

Closing of the bases has led to considerable Congressional reaction. The Senate Armed Services Committee will be asked to consider the whole situation by member Sen. Clifford P. Case (R-N.J.). Sen. George McGovern (D-S.D.) said he will reintroduce his Economic Conversion Act when the Congress convenes in January.

McGovern said that the base closings reemphasizes the need for conversion planning, and that a three- or four-man adjustment assistance office is not enough.

Shots of the Week

NASA on Nov. 21 used a *Scout* vehicle to launch its first double payload into the Earth's upper atmosphere to probe the mysteries of air density and radiation at that level.

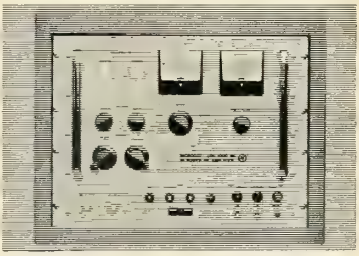
The shot, carrying Air Density and Injun satellites, was postponed from the intended Nov. 19 launch date when a payload separation de-



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Microdot now offers a family of *five* power oscillators, identical except for their frequency ranges which vary from 10 to 1800 mc. The units offer superior performance for antenna evaluation, calibration of power measuring devices, driving amplifiers, providing more than 50 watts between 10-1000 mc and more than 25 watts between 900-1800 mc.

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vice was prematurely activated during prelaunch checkout (M/R, Nov. 23, p. 9).

The Air Density satellite is a 12-ft.-dia. balloon, identical to *Explorers 9* and *19*. It weighs 19 lbs. and is covered with aluminum foil to reflect both sunlight and radio waves. Approximately 4,000 white spots on the surface provide temperature control. When successfully launched, it was designated *Explorer 24*.

The Injun satellite, designed to measure bombardment of the Earth's atmosphere by energetic particles, weighs 90 lbs. Built for NASA by scientists at the University of Iowa, the satellite is roughly spherical in shape and measures 24 in. in diameter. Injun has 40 flat surfaces, 30 of them studded with solar cells. It is now designated *Explorer 25*.

Orbital parameters, all close to nominal, are apogee of 1,552 miles for *Explorer 24* and 1,548 miles for *Explorer 25*. Both satellites have perigees of 325 miles, periods of 116 minutes and inclination to the Equator of 81 degrees.

● A second-stage engine malfunction caused one of the four *Pershing* tactical missiles launched Nov. 18-19 from White Sands Missile Range to impact off the range near Creede, Colo. The errant missile was the fourth shot, launched Nov. 19. The preceding three firings were all successful. All launches were conducted by batteries of the 3rd Battalion, 84th Artillery, Ft. Sill, Okla.

Gratuity Ban Effects Vary

The Dept. of Defense directive banning DOD military and civilian personnel from accepting any lunches, drinks or other gratuities from contractors (M/R, Oct. 5, p. 16) now is in effect. In one of the early reactions, Radio Corp. of America issued a company memorandum instructing its employees to refrain from buying lunches for any government officials.

RCA said it extended the policy to all government officials in order to "treat all customers alike."

A number of other industry firms put into effect or continued a policy of not keeping records of government personnel entertained on business expense accounts. Several firms also made it known that they refused to reveal such names during the General Accounting Office probe into expense accounts (M/R, Nov. 23, p. 9).

Meanwhile, a spokesman for the House Armed Services Special Investigating Subcommittee denied reports that GAO was carrying out its investigation on behalf of the subcommittee. It was explained that the group, headed by Rep. Porter Hardy (D-Va.), is conducting an investigation, but that it is aimed at the activities of Aerospace Corp.

Rep. Hardy said he plans full hearings on the non-profit organization in February. The chairman acknowledged that staff investigators also have looked into the new DOD standards of conduct code, but a subcommittee spokesman said GAO was not involved.

Scandinavians Join Comsat Net

The ground station at Rao, Sweden, about 225 miles southwest of Stockholm, joined the growing world network of communications satellite ground stations Nov. 26.

Taped television messages will be sent to the new station via NASA's *Relay I* satellite from the space agency's ground station at Mojave, Calif.

Associate Administrator Dr. Robert C. Seamans, Jr., and the ambassadors of Sweden, Norway and Denmark took part in the taped program produced by the United States Information Agency. The ambassadors are

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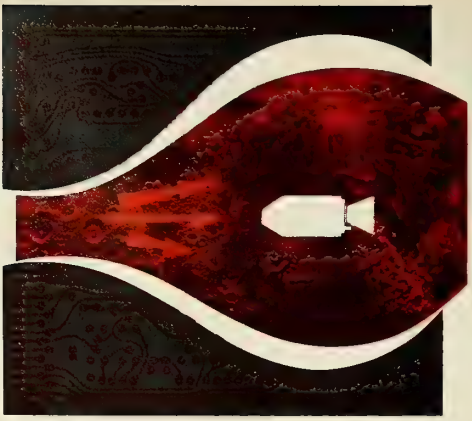
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The 10-minute program will be seen by about five million viewers throughout Scandinavia via a network pickup at the Rao station.

The station is a joint effort of Norway, Denmark and Sweden. These countries join the United States, Britain, France, Germany, Italy, Brazil, Japan and Spain in the communications satellite ground station network.

New Apollo Station Announced

NASA announced that it will establish an *Apollo* tracking station at Honeysuckle Creek, near Canberra, Australia.

Saturn V Low Bidder Named

An apparent low bid of $19,055,953 was submitted by the George A. Fuller Co. of Los Angeles to the Canaveral District of the Army Corps of Engineers Nov. 24 for construction of Pad B of *Saturn V* Complex 39 at Merritt Island, Fla.

Pad B will essentially duplicate Pad A, which has been under construction for a year and is now 60% complete. It is octagonal in shape, covers more than one quarter of a square mile, and rises some 50 ft. above the surrounding countryside. It will be located on the oceanfront north of Pad A.

The pad will be constructed of cellular reinforced concrete and will include buildings to house environmental control and pad terminal equipment, high-pressure gases, facilities for tying down the mobile launch tower, television camera towers, fuel-holding equipment and a sewage treatment facility. The contract also provides for building a two-mile section of crawlerway for transporting launch and arming towers to the pad.

Blount Bros. Corp. and the M. M. Sundt Construction Co. are jointly building Pad A under a $19.3-million contract. Government estimate for the cost of Pad B was $18,306,579.

Realignment at Redstone

Individual missile system offices have been consolidated into two offices in a major management realignment at Redstone Arsenal.

Col. Cyril D. Sterner has been named head of the Land Combat Commodity Office and Col. Richard Irvin, Jr., has been chosen to manage the Air Defense Commodity Office.

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The Air Defense Commodity Office will be responsible for directing the target missile, multi-system test equipment and division air defense systems programs.

Beckman Wins STARS Contest

Beckman Instruments Corp. has been picked by NASA's Goddard Space Flight Center to negotiate a contract for the second phase of the space agency's Satellite Telemetry Automatic Reduction Systems (STARS) program.

The Fullerton, Calif., firm won the award, expected to be worth more than $1 million, in a contest with Electro-Mechanical Research, Inc., of Sarasota, Fla.

Beckman will design and develop three STARS II units, each consisting of telemetry equipment for providing raw data for computer processing. This system is a follow-on to STARS I, which has been employed at Goddard to process data from smaller scientific satellites. The new system will provide GSFC with increased capability to handle the bigger volume of data expected to be produced by observatory-class satellites.

Communications RFP's Asked

RFP's are due Dec. 17 on a Manned Spacecraft Center study to determine the feasibility of laser communications for long-distance space travel.

The study, last in a series of three, calls for investigation of a system capable of providing television, voice and telemetry communications on a single laser beam over ranges up to 50-million miles from Earth.

NASA officials emphasized that the study is for post-*Apollo* applications and involves feasibility only. If hardware follow-on is funded, it is to be packaged, rather than breadboarded, with minimum space and weight, MSC officials said.

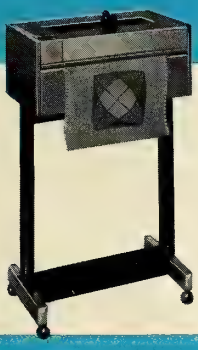
Requirements include a bandwidth wide enough to accommodate a 5-mc TV channel, 4-dc voice and 1-kc telemetry channel, with space for additional telemetry channels to be included later.

The two previous studies include

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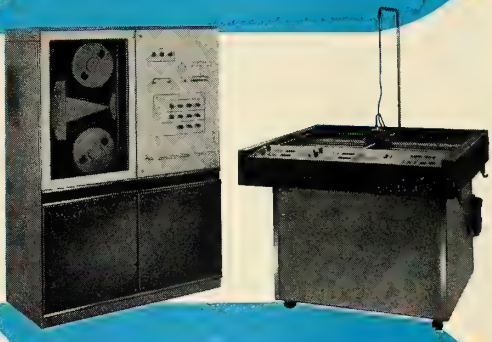
The Boscar Model S is a solid-state semi-automatic reader for rapid reduction of coordinate locations on film to digital form suitable for computer entry. Designed primarily for the reduction of 16, 35 or 70mm photo-theodolite film data, the Boscar Model S may be used for a variety of film-reading tasks.

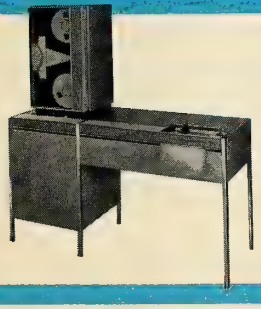




The Draftomatic Incremental Plotter operates from direct digital commands at a speed of 18,000 steps per minute with a high resolution of .005 inches. The plotter is designed to operate on-line for quick-look hard copy or sophisticated on-line time shared display of computer output. The Draftomatic will produce fully annotated plots under complete computer control. It is the fastest, most reliable digital plotter available today.

The Benson-Lehner Magnetic Tape Plotting System is a completely self-contained automatic plotting system, capable of producing fully annotated plots from computer magnetic tapes. The plotting system can produce hundreds of plots from one 2400-foot magnetic tape reel that takes less than 5 minutes of computer time to write on most digital computers. The tape transport is designed to read computer tapes continuously. It accepts tapes written in 200, 556 and 800 bpi densities in gapped or gapless format.





The Draftomatic Magnetic Tape Plotting System produces an X-Y plot from data recorded on magnetic tape by digital computers (or any computer writing IBM-compatible tape). Flexibility of the system permits the use of sub-routines for generation of any desired symbols, letters, numerals, or scale markings. Data is plotted in either a continuous curve or discrete points.

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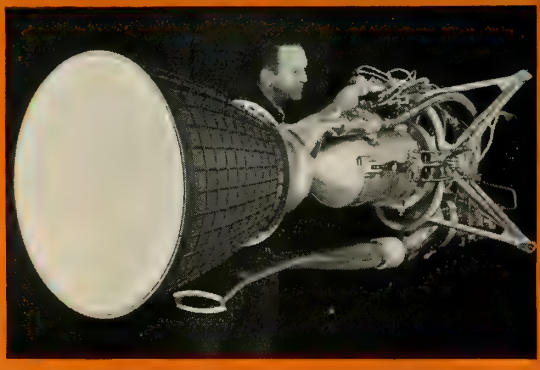
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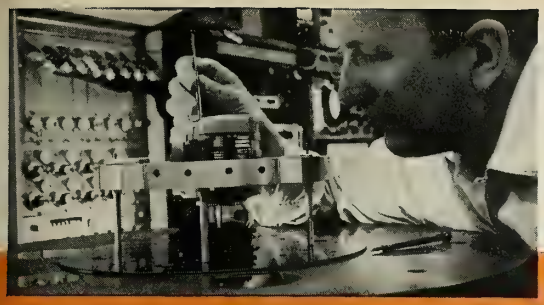
MEANS FACILITIES — Striving for perfection, Bell recently opened a new 20,899 square-foot clean room building constructed at a cost of $700,000. It includes Class 4 facilities and expands Bell's total clean room area. These facilities are used for the production of gyros, inertial platforms and optical equipment . . . the testing of accelerometers and velocity meters . . . and the assembly of Bell's HIPERNAS (High Performance Navigation System), which is a versatile, pure inertial guidance system of proven reliability that can pinpoint a long-range missile on target or guide a satellite or space ship to any point in the universe.



MEANS PERFORMANCE — Agena rocket engines, in production at Bell since 1958, have put more scientific payload into space than all other rocket engines combined. Including more than 100 firings in space, the Agena has a demonstrated reliability record of 99.7% . . . is used on Mariner, Ranger and other programs . . . will be used on future space efforts.



ONE HUNDRED PERCENT RELIABILITY! The Bell Rocket Belt, the only device of its type known to exist today, made its first flight on April 20, 1961. It has since made over 1200 flights on four continents, the majority on a split-second schedule under varied weather conditions, with a perfect reliability record.



MEANS ACCURACY—Assembling a Brig II gyro for Bell's HIPERNAS (High Performance Navigation System.) This compact, lightweight pure inertial navigation system has been selected for the AN/USQ-28 program. It will perform the navigation mission and stabilize cameras with the high degree of accuracy required for ultra-precise U. S. Air Force mapping and survey operations.



MEANS TESTING — Environmental Test Laboratory showing test benches, temperature-altitude chambers and a space chamber. Tests on everything from simple components to large complex systems are performed here and with the 8,000 pieces of commercial test equipment available. In the field of environmental testing, Bell is equipped to perform comprehensive reliability tests and to meet Mil Specs for all equipment.



MEANS INFORMATION — The Electronic Data Processing Center contains a new IBM 7090 high speed computer and two-tape 1401 computers as off-line equipment. The Center handles computations for all phases of aircraft, avionic and rocket engine design and reliability testing. A multichannel Beckman 210 analog-to-digital converter provides data to the 7090 minutes after firing.



MEANS DEPENDABILITY — The only reaction controls used by man in space. These controls were originated in 1953 when it was found that conventional aerodynamic control surfaces are ineffective at extreme altitudes. The Bell controls have since performed successfully on all Mercury and X-15 flights.

MEANS PEOPLE — An aggressive 12 session training program prepared by the Quality Department presents actual current exhibits forceably demonstrating reliability as a "peoples" responsibility. Over 60% of total employment attend. The audience consists of personnel from Manufacturing, Quality, Procurement, Engineering, Program Management, Sales Engineering and Maintenance Departments.



MEANS PROGRESS — The Lunar Excursion Module ascent engine represents one of the most difficult Apollo development items . . . and must bring man back from the moon. Burning storeable hypergolic propellants, the engine has a thrust of 3,500 pounds. This ablative engine has a reliability goal of 100%. A major step towards this achievement has been a recent successful full duration altitude firing of the thrust chamber.



Bell's record of reliability as presented in pictures and captions on these pages speaks for itself. Agena Engine — 99.7% demonstrated reliability including more than 100 firings in space, Reaction Controls — have performed on every Mercury and X-15 program, Rocket Belt — 100% reliability in over 1200 flights. Reliability is not a new word at Bell . . . it has been a way of life throughout the Bell organization for years . . . it is an inherent characteristic of all Bell-built equipment.

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Saturn . . . the dependable booster of the space age

On January 29, NASA's Saturn SA-5 lifted off from the pad at the John F. Kennedy Space Center carrying the first live S-IV second stage and the heaviest payload ever orbited—more than 37,000 pounds.

It thus established beyond a doubt the dependability of Saturn I, and its fitness for the key role it will play in our nation's space exploration program.

The role of the upcoming Saturn IB in the NASA Apollo program will be to earth orbit manned Apollo spacecraft vehicles for tests of the rendezvous and docking methods to be used in later manned lunar landing flights.

It is also the logical vehicle for all programs where relief from the present weight and space restrictions on payload are desired.



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one by Radio Corp. of America for investigation of the Sun-pumped laser concept and an IBM Corp. solid-state laser under consideration as a Project *Gemini* experiment.

California Tops in Primes

California again led the other states in the value of prime contracts awarded defense industries for the first quarter of Fiscal Year 1965.

The state received 21.2% of the prime award dollars, valued at $1,188,373,000. the Pentagon quarterly report showed. For the first quarter of FY '64, California showed $1,345,757,000 for 21.1% of the total.

Prime awards for the July-September period amounted to $6,327,516,000. The total was down $680,130,000 from the first quarter total for FY '64. Following California in the FY '65 ranking were Texas with 9.6%, New York with 6.7%, Massachusetts with 6.1% and Georgia with 5.8%. Massachusetts showed the largest first-quarter gain of any state, moving from ninth position in Fiscal '64 to fourth in Fiscal '65.

Prime awards are those totaling $10,000 or more. Since the quarterly report reflects value of prime contracts only, it does not in any way reflect distribution of a "very substantial amount" of material and component fabrication and other work and services performed outside the states where final assembly takes place, the Pentagon said.

Stratoscope II Balloon Bursts

The Nov. 25 launch of Stratoscope II was delayed at least 48 hours when a tube being used to fill the 300,000-cu.-ft. balloon with helium slipped and punctured the thin plastic skin. Another balloon was to be sent to the Palestine, Tex., launch site from the G. T. Schjeldahl Co. in Northfield, Minn.

The second launch in the Stratoscope program involves sending a 36-in. telescope to an altitude of 15 miles aboard a balloon to photograph the planet Jupiter.

SNPO Gets Division Status

The NASA/AEC Space Nuclear Propulsion Office will take on division status this week following a three-way split in the Div. of Reactor Development.

SNPO and the two other new divisions—Div. of Reactor Development & Technology and the Div. of Naval Reactors—will now report to Dr. John A. Swartout, named assistant general manager for reactors. Dr. Harold B. Finger will continue to direct the SNPO Div., responsible for the *NERVA* program.

AEC's SNAP program, formerly under the Reactor Div., will now be one of six major program areas in the Div. of Reactor Development & Technology. Director will be Milton Shaw, who has been technical assistant to the Assistant Secretary of Navy for R&D.

Vice Adm. H. G. Rickover will direct the Div. of Naval Reactors.

WEC Gets ATS Pact

Westinghouse Electric Corp.'s Defense & Space Center has received a NASA contract for communications integration of contractors for the *Applications Technology Satellites (ATS)* tracking station at Rosman, N.C.

The contract, now being negotiated with Goddard Space Flight Center, calls for additional work, including some instrumentation and design of a master control console for communications experiments, telemetry data and data processing.

The *ATS* program involves the launch of five 650-lb. satellites, beginning in 1966. Three tracking stations will be used—Rosman, Mojave, Calif., and a 40-ft. portable ground station.

Ryan New SAC Boss

Lt. Gen. John D. Ryan will take over this week as commander of the Strategic Air Command. He succeeds Gen. Thomas S. Power, who is retiring.

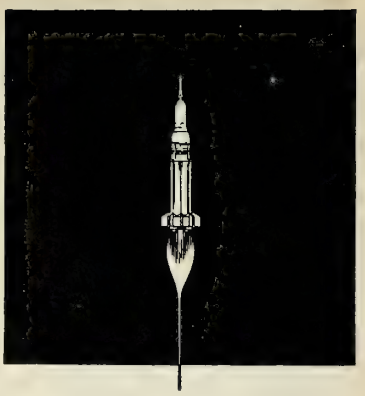
Ryan, 48, has been serving as SAC vice commander. His promotion brings him nomination for the rank of a four-star general.

Lt. Gen. Joseph Nazzaro, now commander of SAC's Eighth Air Force, will succeed Ryan as vice commander.

TRW Faces Patent Troubles

Financial sanctions against contractors in the form of liquidated damages for failure or delay in complying with Dept. of Defense patent provisions have been recommended by the General Accounting Office.

The recommendation was precipitated by a GAO study of several divisions of Thompson Ramo Wooldridge, which it said was not complying with various patent provisions of its defense contracts. GAO Comptroller Joseph Campbell said that 18 inventions made under defense contracts up to three and a half years earlier were never disclosed to DOD. For some of these, the report said,



Positions open at New Orleans

AEROSPACE PHYSICS

ACOUSTIC and VIBRATION ENGINEERS and SUPERVISOR

Primary experience should be in unsteady phenomena such as aerodynamic noise and vibration. Will direct prediction of complete aerodynamic environment of Saturn and advanced Saturn vehicles. Also direct the establishment of shock and vibration criteria corresponding to the predicted environment, including acoustics and buffeting. Minimum 5 years experience.

FLIGHT DYNAMICS ENGINEERS and SUPERVISORS

To perform dynamic analyses for frequencies and mode shapes of elastic structures; stability analysis of elastic vehicles to determine control filter requirements and tank baffling; response of elastic vehicles to winds to determine maximum bending moments, shear loads and trajectory errors.

FLIGHT MECHANICS ENGINEERS and SPECIALISTS

. . . with experience in flight path optimization, propellant loading analysis, impact dispersion of spent stages, rigid body control, dynamics of stage separation, determination of abort sensing parameters, lift off motion studies, pre-flight and range safety analysis. Must be familiar with theoretical trajectory digital simulation techniques.

FLUID MECHANICS ENGINEERS and SUPERVISORS

To supervise selection and development of analytical and experimental techniques for solutions to fluid dynamic problems (aerodynamic and structural heating, cryogenic storage, boundary layer theory, reaction kinetics and ablation, fluid flow problems and gas dynamics).

Positions open at Cape Kennedy

LAUNCH TEST SUPERVISOR

BSEE with minimum 10 years missile systems or related experience. Will be responsible for overall direction of Chrysler launch test operations. Requires current state-of-the-art test conductor and operations management experience.

TEST CONDUCTOR

BSEE with minimum 8 years missile systems experience. Current launch test conductor experience required.

GSE STAFF ENGINEER

BSME with minimum 8 years missile systems experience and current state-of-the-art experience in GSE design and operation.

Senior engineering positions also open in Propulsion, Electrical Networks and Telemetry.

Excellent positions in other disciplines are also open at Huntsville as well as at New Orleans and Cape Kennedy

SPACE DIVISION CHRYSLER CORPORATION

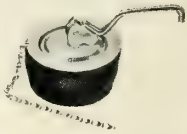
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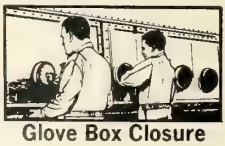


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Industrial research and product development create many difficult sealing problems. Moeller engineers solve such problems almost every day. They are available for conference and cooperation with your staff so, if you need help, call us in early. Our plant is self-contained for reliable processing and manufacturing. Your inquiries are invited.



Atomic Fuel Charging Plug
Made for GE. Used at Hanford Atomics Operation. Expansion-type plug withstands high-level gamma and neutron radiation, temperatures to 150 degrees F.



Glove Box Closure
Improves safety factor in handling plutonium. Closure holds under pressure, provides positive seal with quick access.



Nose Cone Closure
Made to highest specifications. Used to keep moisture, and dust from vital equipment during pre-launch period.

FOR MORE INFORMATION WRITE—

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patent applications were on file. In another case, the contractor delayed disclosures of "numerous inventions" for "unreasonable" periods.

Because of these violations, GAO said, the government's patent rights were jeopardized since it was not aware of the inventions, and may have actually paid royalties unnecessarily for the use of them. It may also have lost its right to such inventions because of intervening patents by third parties.

U.S. R&D Property Worth $4.4B

Total cost of U.S.-owned property used for research and development is now estimated at $4.4 billion, a House special committee has found.

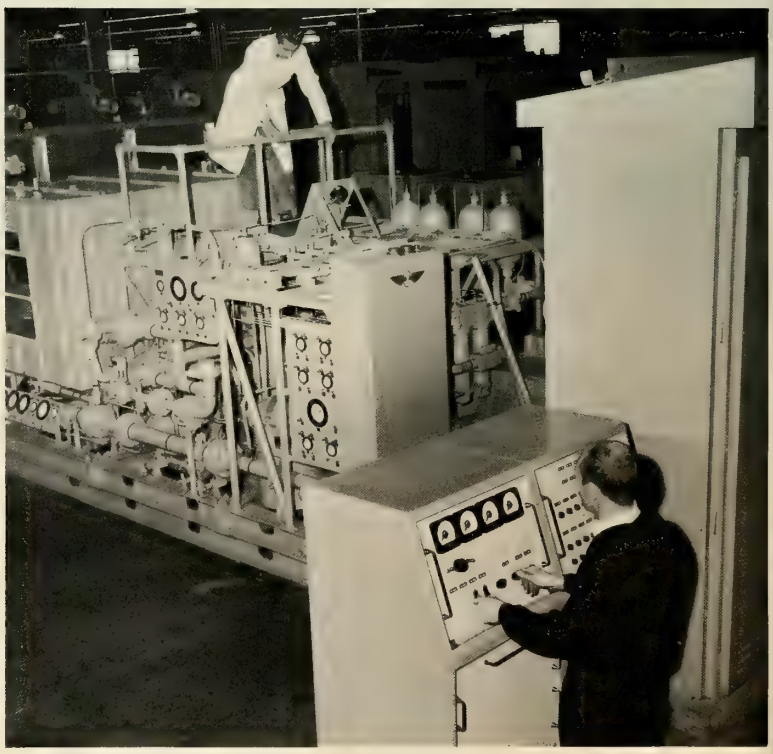
While the General Services Administration's estimates for facilities has been $2.5 billion, the House Select Committee on Government Research said that this is the first complete inventory of the facilities.

California, first in all other R&D categories, also leads in total floor space devoted to R&D with 28,296,-211 square feet. New Mexico, Florida, Maryland, Alabama and Virginia follow.

Document Coordination Sought

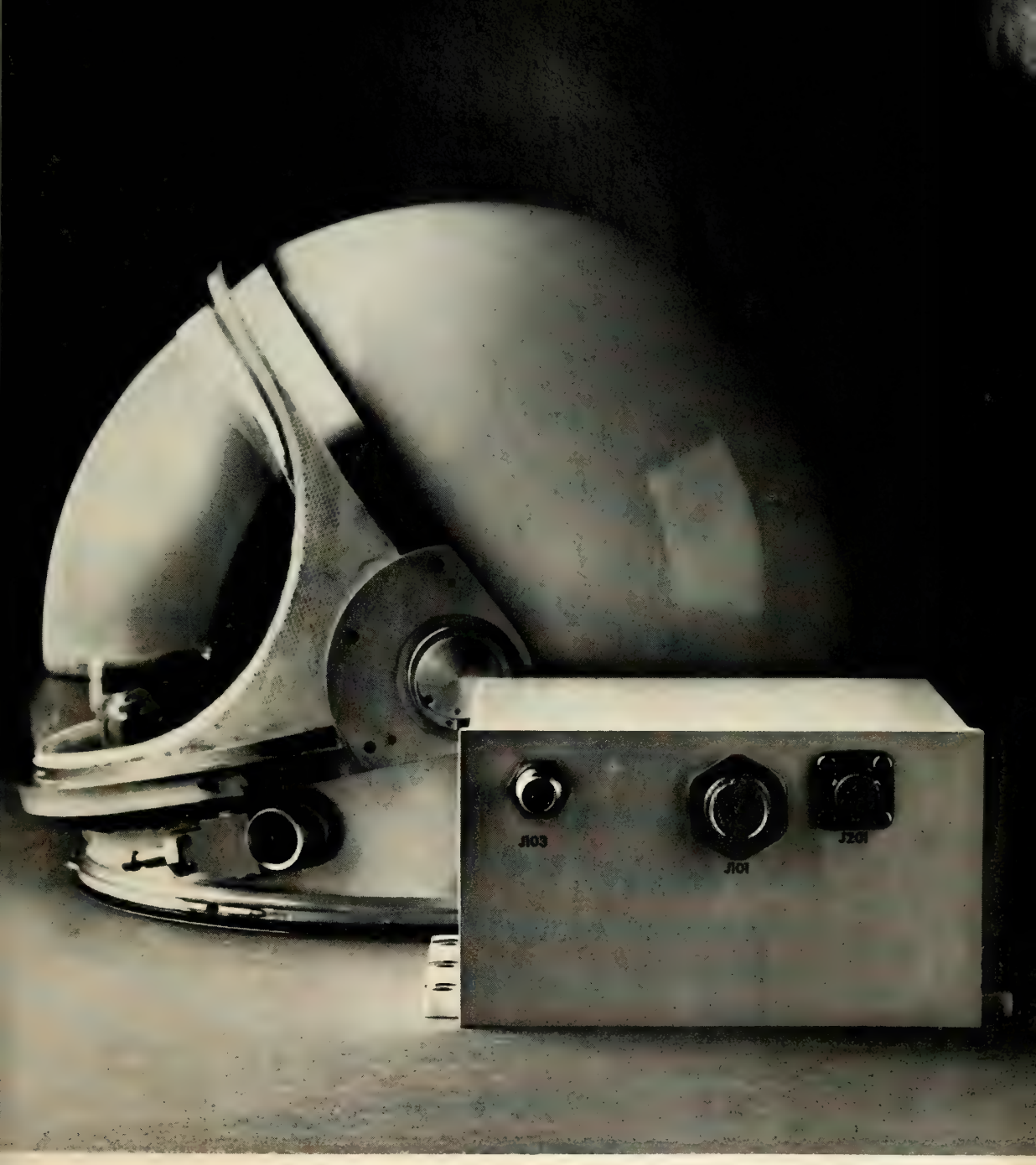
A Congressional committee has called for a coordinated effort in attacking the problem of scientific documentation and dissemination of research and development results—a field now inviting waste and inefficiency, it said.

The House Select Committee on Government Research recommended that one central source such as the Committee on Scientific and Technical Information (COSATI) enforce cooperation among government agencies. While COSATI may have "the teeth" to enforce this cooperation, the Congressional committee said, it has not yet shown them.



Shaving Weight from Saturn V

THIS 36,000-LB. hydraulic power supply unit will trim 3,000 lbs. from the launch weight of the Saturn V. The $1.250-million device will supply all necessary hydraulic power to the vehicle during its 36-hr. countdown. It will keep the rocket's hydraulic systems exercised, preventing freezing while cryogenic oxidizer is pumped aboard. At firing, the unit will be cut off, and booster fuel will operate hydraulic systems for the few minutes such power is needed. The unit was designed and built for NASA by Greer Hydraulics, Inc., Los Angeles.



Just checked in from outer space

ACF Electronics radar transponders have kept track of all the Mercury missions and are now scheduled to do the same for the Gemini and Apollo flights. ACF Electronics is now developing other transponders for advanced space applications—including a pulse coherent beacon. For information on any of these new developments, or on new microwave techniques in progress at ACF, write or call: ACF Electronics, ACF Industries, Incorporated, 11 Park Place, Paramus, New Jersey.

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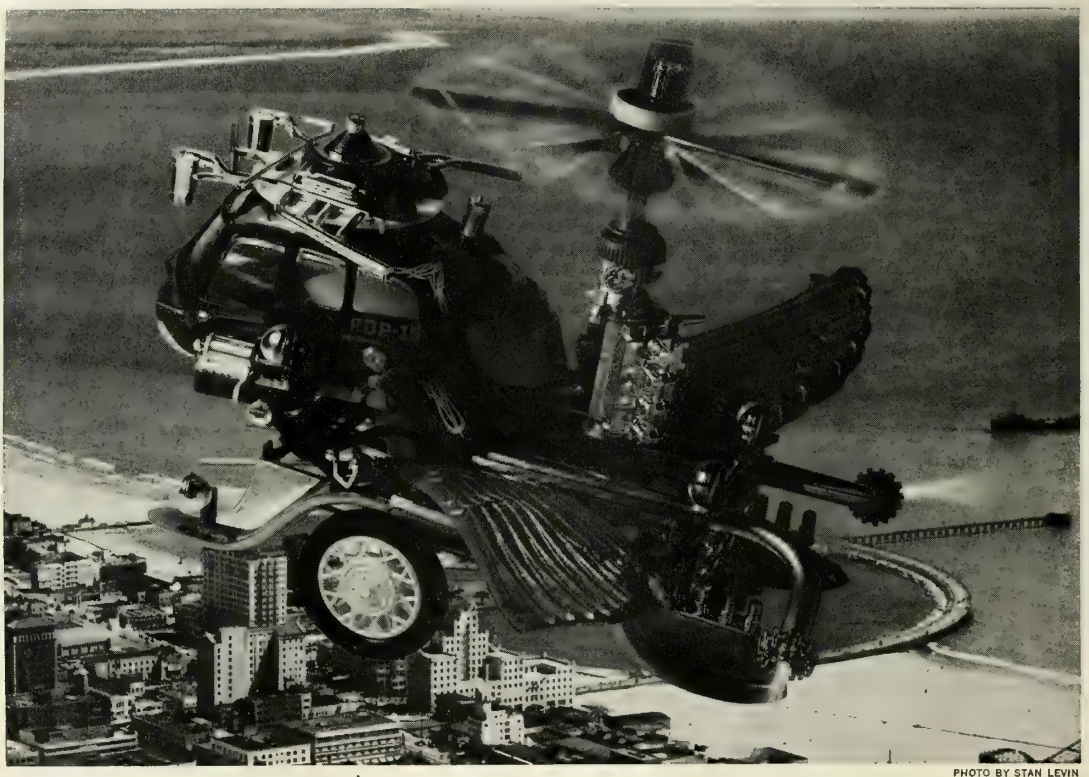


PHOTO BY STAN LEVIN

FIRST PHOTO PDP-15

In an effort to stay current on DOD requirements, we have set up and put in work our own Program Definition Phase committee. The committee, working in concert with various GCC design and manufacturing teams, can be credited with successful completion of our PDP-15 vehicle shown above in test flight. The PDP, a remarkable ~~interceptor-bomber-~~ ~~recon-strike-~~ ~~strike-recon-reentry vehicle~~ ~~borate-bomber-~~ black thing, was designed, program defined and constructed from scratch in only two thousand, seven hundred and forty-six days. (Use Reader Service #10 for framable photo.)

Color TV Monitor

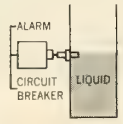


This compact 17″ unit requires only 21 vertical inches or a standard 19″ rack or console. Weighs less than 100 lbs. Unparalleled resolution and color fidelity. Made by our Conrac Division, which is notable for making the best professional monitors anywhere. Ask any broadcast engineer.

Air Data Computer

Used on helicopters. Gives accurate, low-speed (0 to 100 mph) readings for forward, reverse, port and starboard or any combination thereof. Pressure signals are generated by sensors mounted on rotor tips. Neat trick.

Ultrasonic Fluid Level Controller

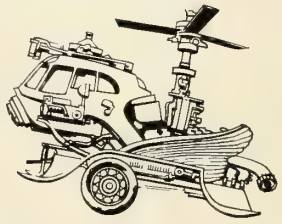


This probe-type system senses the presence or absence of fluid at any point or points in a flow or storage system. No moving parts. Takes highest random vibration ever. Works regardless of pressure, temperature, physical or electrical nature of the fluid. Accurate. Safe. Reliable. Repeatable.

Min. Elapsed Time Indicator



Made by our Cramer Division to last despite MIL-shock and vibration. Body size is 1″ x 1¼″ weight is 6 ozs. Life expectancy is up to 30,000 hours (10,000 guaranteed).



WIN SCALE MODEL

In the left and right columns, you will find descriptions of seven GCC products. If you can figure out where we've used each of these products in the design of the PDP-15 and describe five possible uses for the vehicle itself, you may be the winner of our prototype scale model (there can only be one big winner since we have only one model, but all entrants will receive their just rewards).

1″ by 1″ Pressure X'ducer



The smallest, lightest potentiometric transducer ever. Comes in high and low pressure versions. Covers 0 to 3,500 psia. Low pressure one is stable to 50G's vibration and acceleration (up to 75G's for the high pressure version). Weighs 3 ozs. Temperature range is −65°F to +200°F.

Stall Warning X'ducer

Among other things, provides inputs to our GCC Stall Warning Systems. The transducer itself, in its two most popular versions, is the 2566-B727 and the 2566-BAC111. In both cases, we make the 2566 part. Boeing and British Aircraft make the 727 and 111. There's also a military version, the 2562. It is not used on the PDP-15 (above) since the program has been in full stall from the start.

Shaft Position Encoder

Datex encoders are made by our own Datex Corporation. Datex makes all sorts of encoders. And those they don't make, shouldn't be.

Technical Countdown

ASTRONAUTICS

Non-coplanar Ascent Suggested

Space station logistics operations should be carried out by use of non-coplanar ascent to rendezvous, suggests Jacques S. Gansler, of General Precision Inc.'s Aerospace Systems Div. A velocity penalty of about 5% over the coplanar approach is incurred, but much greater flexibility of launch opportunity is obtained, together with elimination of the 12-hour parking in space requirement, he claims. A total of three impulses is required for rendezvous: the first establishes the ascent ellipse; the second establishes an intersecting orbit, being applied at apogee; and the third is applied at intercept to eliminate the plane angle, said Gansler.

Mars Contacted at Farthest Distance

Successful radar contact by the Arecibo, Puerto Rico, Ionospheric Observatory was made on November 19 with Mars, now situated at its greatest distance from Earth. Traversing some 138 million miles with the facility's 1,000-ft.-dia. spherical radar antenna, Cornell University scientists noted that continuous observations can be made of the red planet from Arecibo until late June, 1965. Such studies will greatly increase knowledge of the planet's orbit and contribute later to the growing fund of interplanetary navigational data.

ELECTRONICS

Fairchild Declared Primary Planar Owner

Fairchild Camera & Instrument Corp. has been recognized by the U.S. Patent Office as owner of 16 of the 17 claims contained in two patents covering the Planar active semiconductor component process and structure. In two recent decisions, the Patent Office refused 16 claims of an interference filed by Hughes Aircraft Co. Although the Patent Office decided to permit Hughes to contest ownership of the one remaining claim, Hughes has agreed to assign that claim to Fairchild under a cross-licensing arrangement. According to Dr. Robert N. Noyce, general manager of Fairchild Semiconductor, this decision "establishes Fairchild's indisputable ownership of the Planar patents. The Patent Office will entertain no further interference attempts because the one-year time limit has expired since the patents were issued." Noyce added, "With the Planar patents now clearly established as our property, we will step up our program to license all manufacturers of semiconductor devices using this process before we take any legal action to enforce our patents."

EOS Microscope Offers New Potential

Electro-Optical Systems, Inc., has developed a high-temperature, ultra-high-vacuum thermionic electron-emission microscope. The instrument's extreme operating characteristics permit researchers for the first time to pictorially record critical problems associated with metal-phase and grain-growth change in missiles and hypersonic aircraft. EOS scientists emphasize that the microscope allows studies of refractory metal grain growth and recrystallization phenomena while these processes actually occur—a capability never before achieved at such high temperature. The unit operates at temperatures from 1,300° to over 1,800°C and at vacuums from 10^{-7} to 10^{-8} torr. It reportedly exceeds running temperatures of similar microscopes by several hundred degrees and functions at pressures lower than other such devices by a factor of 10.

Tiny GaAs Laser Transmits Audio Signals

A 12-oz. gallium-arsenide injection-laser transmitter, developed by IBM's Federal Systems Div., operates on less than 1.5 watts average power providing peak-pulse outputs of ½ watt. Demonstrated at the recent Association of the U.S. Army Convention in Washington, the uncooled laser operated at a wavelength of 9,000 Angstroms with a beamwidth of 12 arc seconds. Six inches long and provided with a pistol-grip configuration, the device was used to convert and transmit audio signals over short range. Frequency response of the system is from 300 cps to 3 kc.

SPACE MEDICINE

Sixty-Day Isolation Studies Planned

The Air Force is planning to isolate volunteer subjects for as long as two months to study the effects of stress, fatigue and isolation in space cabin situations. First test in the new program, directed by Dr. Bryce O. Hartman and Maj. George K. Cantrell of the AF School of Aerospace Medicine, was a five-day "shakedown" test in the new double-decker isolator fashioned from two RB-52 aircraft fuselages refurbished by Southwest Research Institute for AF research. Subjects were tested for concentration, memory recall, reaction time in response to vehicle movements, logic and problem solving ability.

MATERIALS

PH 13-8 Mo Alloy Forged By Wyman-Gordon

A combination disc and shaft part has been successfully forged in PH 13-8 Mo alloy by Wyman-Gordon Co. Developed by Armco, the alloy is a single heat treatable material possessing a capability of developing strength in excess of 200,000 psi yield combined with good toughness and good transverse direction properties. The composition is free of delta ferrite at forging and room temperatures, which significantly improves its forgeability. With the elimination of the delta ferrite problem, it is possible to use forging designs and techniques normally employed in producing parts from the martensitic stainless steels. The micro-structure after the forging and aging treatments was of a fine tempered martensite similar to the maraging steels.

Metal Processes Observed by Microscope

A high-temperature, ultra-high-vacuum thermionic electron emission microscope developed by researchers at Electro-Optical Systems, Inc., is being used to observe metal phase and grain growth changes. The unit operates at temperatures from 1,300°C to over 1,800°C and at vacuums from 10^{-7} to 10^{-8} torr. In one experiment, the annealing process in molybdenum was observed at high temperatures for an extended time. The annealed sample was first abraded with a scribe and then observed continuously for 200 hours at 1,500°C. The abrasion annealed within 124 hours. The development grew out of a $142,700 contract from NASA's Lewis Research Center covering studies of electrode materials for thermionic energy converters.

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when and where

DECEMBER

5th Annual Meeting of the American Institute of Chemical Engineers, Statler Hilton Hotel, Boston, Dec. 6-10.

Third Conference on Performance of High Temperature Systems, Huntington-Sheraton Hotel, Pasadena, Calif., Dec. 7-9.

Third Annual Western Contamination Control Congress, sponsored by the Western Regional Chapter of the American Association for Contamination Control, Lafayette Hotel, Long Beach, Calif., Dec. 9-11.

Symposium on High-Energy Astronomy, sponsored by Air Force Office of Scientific Research, Atomic Energy Commission, NADA, National Science Foundation, Office of Naval Research, and the University of Texas, University of Texas, Austin, Dec. 15-18.

131st Annual Meeting, American Association for the Advancement of Science, Montreal, Canada, Dec. 26-31.

JANUARY

Eleventh National Symposium on Reliability and Quality Control, sponsored by the American Society for Quality Control and the Institute of Electrical and Electronics Engineers, Fountainebleau Hotel, Miami Beach, Jan. 12-14.

International Symposium on Solar Radiation, sponsored by the American Society for Testing and Materials, International Hotel, Los Angeles, Jan. 18-21.

Winter Meeting of the National Society of Professional Engineers, Jung Hotel, New Orleans, Jan. 20-23.

National Syposium on Hydrocarbon Analysis, sponsored by the American Society for Testing and Materials, Sheraton-Lincoln Hotel, Houston, Jan. 22-23.

Symposium on Fundamental Phenomena in the Material Sciences, sponsored by the Ilikon Corp., Sheraton Plaza Hotel, Boston, Jan. 25-26.

Joint Annual Meeting of the American Mathematical Society and the Mathematical Association of America, Univ. of Colorado, Denver, Jan. 25-30.

FEBRUARY

Reinforced Plastics Division Conference, sponsored by the Society of the Plastics Industry, Edgewater Beach Hotel, Chicago, Feb. 2-4.

Winter Convention on Military Electronics, sponsored by the Institute of Electrical and Electronics Engineers, Ambassador Hotel, Los Angeles, Feb. 3-5.

Unmanned Exploration of the Solar System, sponsored by the American Astronautical Society, the American Astronomical Society, American Geophysical Union, American Institute of Biological Sciences, Institute of Electrical and Electronics Engineers, and the American Institute of Aeronautics and Astronautics, Denver Hilton Hotel, Denver, Feb. 8-10.

Spring Meeting of the American Society for Testing and Materials, Statler-Hilton Hotel, Cleveland, Ohio, Feb. 8-12.

1965 Electrical and Electronic Trade Show, sponsored by the Electrical Representatives Club and the Electronic Representatives Assn., Denver Auditorium Arena, Denver, Feb. 15-17.

Sixth Annual West Coast Reliability Symposium, sponsored by the American Society for Quality Control—Los Angeles Section, and the University of California at Los Angeles—Engineering Dept., UCLA Campus-Moore Hall, Los Angeles, Feb. 20.

MARCH

Symposium on High Speed Testing, Sponsored by Massachusetts Institute of Technology and Brooklyn Polytechnic Institute, Sheraton Plaza Hotel, Boston, March 8-9.

Aviation and Space Conference, sponsored by the American Society of Mechanical Engineers, Statler Hotel, Los Angeles, March 14-18.

International Convention of the Institute of Electrical and Electronics Engineers, New York Hilton Hotel and New York Coliseum, New York City, March 22-25.

Symposium on Thermophysical Properties, sponsored by the American Society of Mechanical Engineers, Purdue University, Lafayette, Ind., March 22-26.

Spring National Convention of the Society for Nondestructive Testing, Los Angeles, March 22-26.

Optical Society of America Meeting, Statler-Hilton Hotel, Dallas, March 31-April 2.

APRIL

International Symposium on Fission Product Release and Transport Under Accident Conditions, sponsored by the Oak Ridge National Laboratory, Oak Ridge, Tenn., April 5-7.

1965 Annual Region III Meeting of the Institute of Electrical and Electronics Engineers, Robert E. Lee Hotel, Winston-Salem, N.C., April 6-8.

1965 Annual Region VI Conference of the IEEE, Las Vegas, Nev., April 13-15.

15th Annual National Telemetering Conference, sponsored by the IEEE, ISA and AIAA, Shamrock-Hilton, Hotel, Houston, April 13-15.

Symposium on System Theory, sponsored by the Polytechnic Institute of Brooklyn, IEEE, Society for Industrial and Applied Mathematics, AFOSR, ONR, and the Army Research Office, New York City, April 20-22.

Southwestern Conference and Electronic Show, sponsored by the IEEE, Dallas Memorial Auditorium, Dallas, April 21-23.



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Drake's Portable Dial (English—1569) Courtesy The Trustees of the National Maritime Museum, Greenwich, England.

from Drake's dial to orbital guidance

When Sir Francis Drake set sail for Brazil in 1577, he cast superstition aside for an infant science called navigation. He entrusted his ships to a quadrant, magnetic compass, nocturnal, tide-table, star-chart and pelorus ring—all neatly bundled into the compact little instrument shown above. And despite the obvious drawbacks and inaccuracies inherent to his rude tools, Drake became the first Englishman to circumnavigate the world.

Today, "circumnavigation" has a new meaning; now we envision men orbiting the moon. For this complex task, AC is a member of the team developing an entirely new guidance concept for Project Apollo—a concept that optimizes the human intelligence of the astronaut with the most advanced space and navigation equipment developed thus far.

AC has the responsibility for the assembly, integration and test of the complete navigation and guidance system for Apollo, including the Lunar Excursion Module. We will also fabricate the Inertial Measurement Unit, Display and Control Panel, Power and Servo Assembly and Ground Support Equipment.

NASA's faith in our ability to develop and produce this highly accurate equipment is based on past performance. Put this same experience to work for you. Contact Director of Sales-Engineering, AC Spark Plug Division, General Motors Corporation, Milwaukee, Wisconsin 53201.

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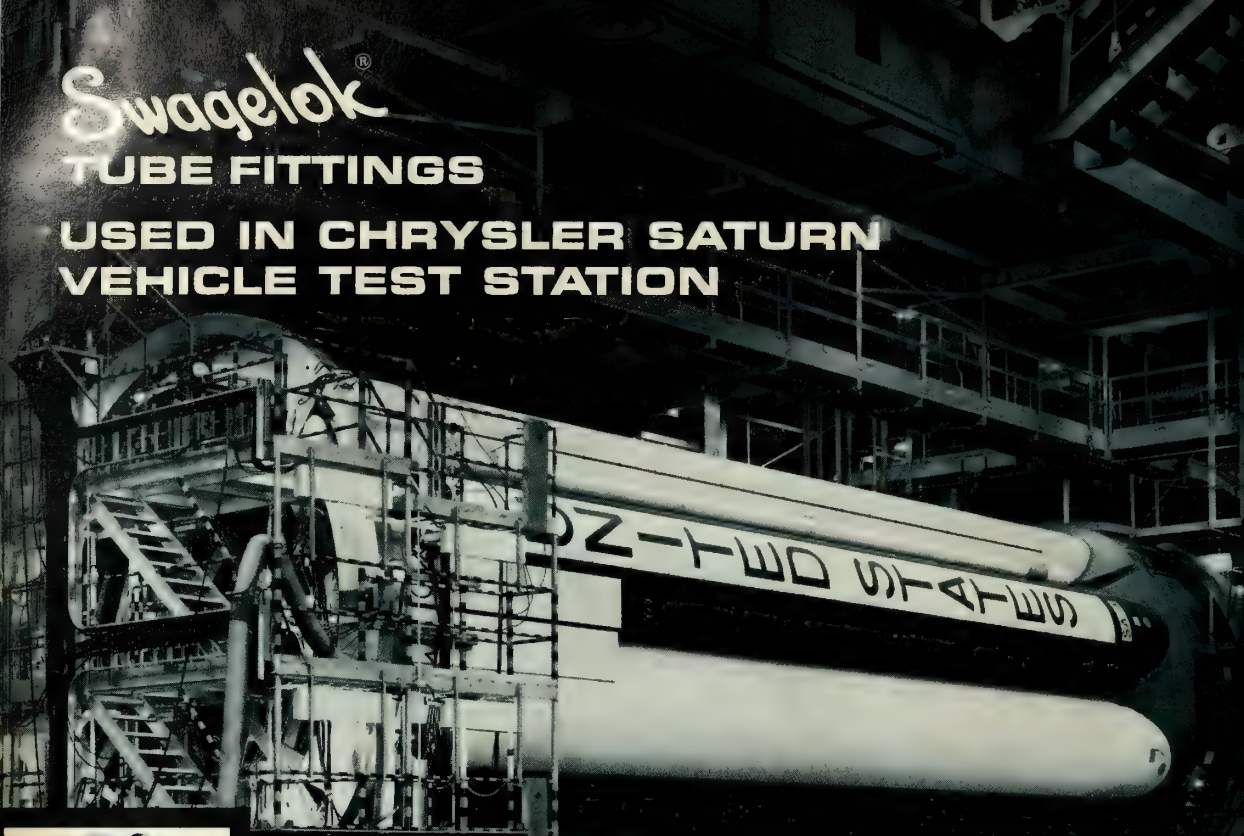
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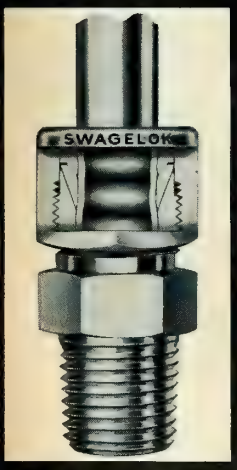
BEYOND APOLLO: THE U.S. BEGINS TO REAP BENEFITS OF ADVANCED TECHNOLOGY AS IT WEIGHS NEW SPACE PROJECTS

AFTER A YEAR OF SOLID if largely unspectacular accomplishment, the U.S. space program is ready to move ahead with the Apollo-X spacecraft —first step toward achieving a true space station. At the same time, NASA is turning its attention to a manned landing on Mars, with initiation of the unmanned Mars Voyager series. Pricetag for the post-Apollo program now under consideration is roughly $15 billion. In addition to the advanced exploration of our Solar System, the space agency is pressing development of new families of Earth-orbiting satellites, exploiting the new technology created during the past several years for immediately practical purposes. Still another aspect of the national space program is the extended exploration of the Moon to be undertaken probably with the modified Lunar Excursion Module. This Fourth Annual NASA Issue of MISSILES AND ROCKETS *also examines in detail, for the first time, the space programs of the Weather Bureau, the Atomic Energy Commission and the Communications Satellite Corporation. Part I of the report covers NASA programs; Part II, NASA organization; Part III, the ComSat Corp.; Part IV, the Weather Bureau; Part V, the AEC; and Part VI, key NASA, AEC and Weather Bureau procurement personnel.*

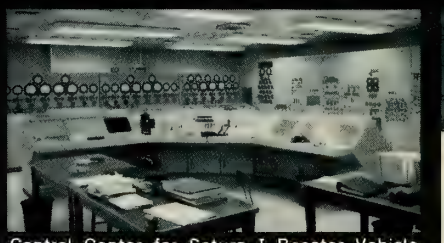
missiles and rockets volume 15 number 22 november 30, 1964

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WEBB: A YEAR OF ORDERLY PROGRESSION TOWARD OUR ASPIRATIONS



SUBSTANTIAL PROGRESS in the peaceful exploration and use of space has marked the year since the appearance of the last special NASA edition of MISSILES AND ROCKETS.

It has been a period of advancement, not only in space, but also on the ground. Extensive construction work is nearing completion on the long-range facilities the Nation needs to build, test and launch the space vehicles which are expanding our frontiers.

At NASA field centers, in laboratories and classrooms of universities, in the factories and board rooms of an ever-increasing sector of American industry, thousands of highly-skilled and innovative men and women are dedicating their best efforts to building a broad array of space competence for the Nation.

Just two days after the last special NASA issue of M/R —on November 27, 1963—the *Centaur II* rocket was fired from Cape Kennedy in the first successful demonstration of high-energy liquid hydrogen as an advanced propellant for upper-stage space rockets.

That important launching was the first of a series of major NASA accomplishments during the past twelve months.

Centaur II was followed by *Tiros VIII;* the first two-stage *Saturn I* in orbit; the first unmanned *Gemini*, which performed well in its programmed 69 orbits; the Project *Fire* spacecraft, which was propelled back into the atmosphere from space to provide necessary design information for future spacecraft applications; the successful tests of the experimental KIWI and *NERVA* nuclear rocket reactors; the sixth successful test launch of *Saturn I;* the second successful *Centaur* liquid hydrogen test flight; the *SERT I*, which proved the feasibility of using ion electric engines in space; *Ranger VII*, which sent back more than 4,000 close-up photographs of the Moon in the most dramatic advance in astronomy since the invention of the telescope; *Syncom III*, which permitted television transmission of the Olympic Games from Tokyo; *Nimbus I*, which made major advances in meteorology and infrared scanning of the Earth's dark side; *OGO I*, which carried a variety of scientific experiments for studying the phenomena of cislunar space; and still another *Saturn* test flight.

While this recital of major space events clearly demonstrates the Nation's growing capability in space endeavors, it does not tell the whole story. Substantial work went forward during the last twelve months on NASA's manned space flight projects, *Gemini* and *Apollo*, even though no manned flights were undertaken in that period.

The *Gemini* program has been scheduled to start manned flight missions early next year. We can now look forward with confidence to gaining in the *Gemini* program the experience our astronauts must have in rendezvous and docking maneuvers that are necessary to the success of the *Apollo* manned lunar expedition.

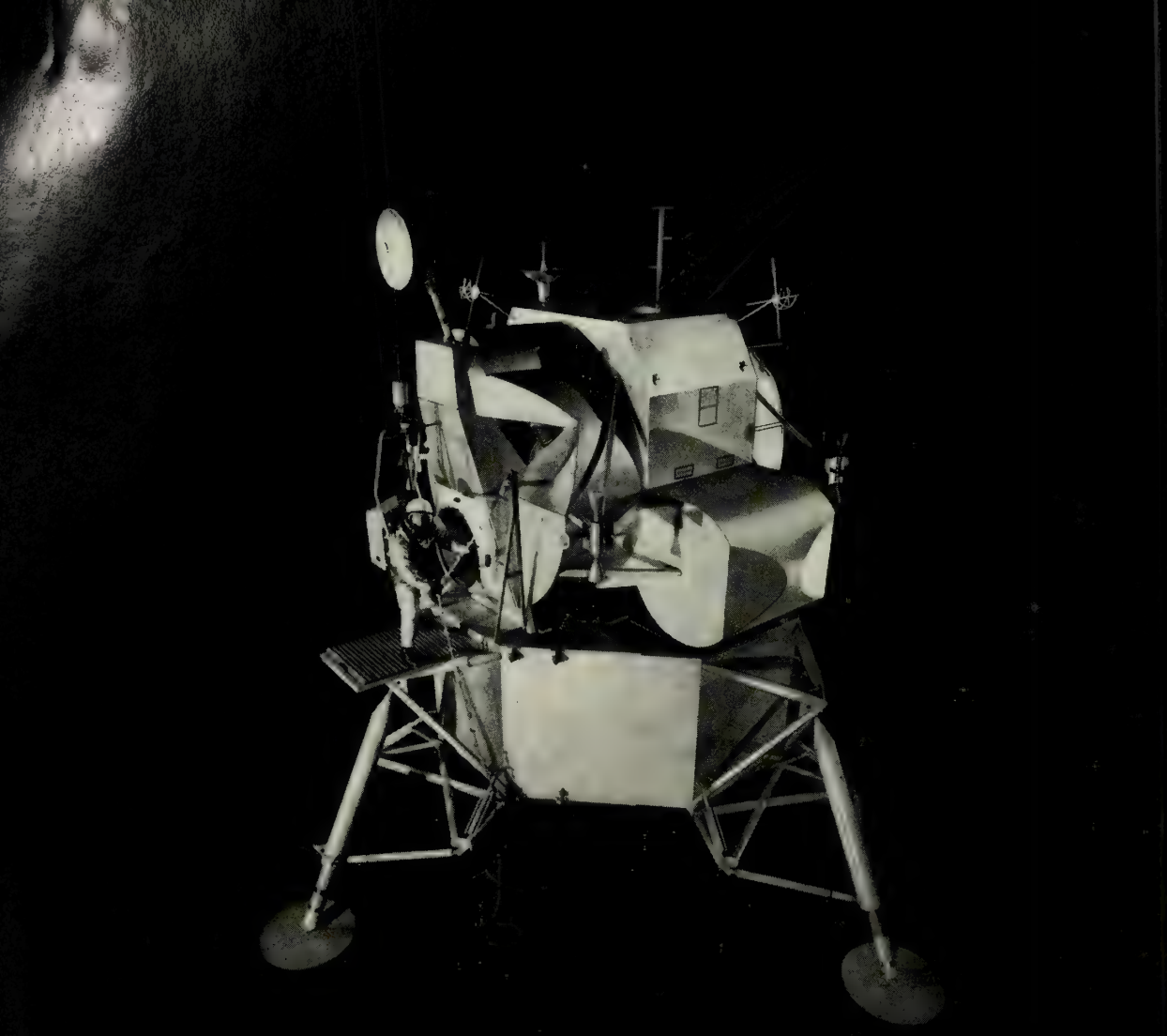
Some 5,000 man-hours of space flight time are scheduled in *Gemini* and *Apollo* spacecraft before the Moon voyage is undertaken. This intensive experience in manned space flight will be gained primarily in near-Earth space, and has important applicability to national defense.

While we continue to reach out into space, we must at the same time strive for improvement of flight within the atmosphere. The ocean of air which surrounds our Earth will become an increasingly important medium of travel in the years ahead. NASA is working in the closest cooperation with the Federal Aviation Agency on the SST. With the *X-15* research aircraft, more than 100 test flights at supersonic and hypersonic speeds, and at altitudes up to more than 50 miles, have blazed the trail toward a true aerospace plane. At the other end of the speed spectrum, important work has gone forward toward developing practical vertical and short takeoff and landing concepts for faster, longer-range helicopters, propeller- and jet-powered aircraft to operate from almost any site.

OUR LONG-RANGE TARGET, in both aeronautics and astronautics, is to build up a reservoir of competence for the United States in every important aspect of aerospace.

The achievements of the past twelve months, and the confidence those achievements have inspired among the national space team, are continuing evidence that the space program is moving in orderly progression toward its aspirations.

James E. Webb



Grumman's across-the-board space capabilities: 1965-1975

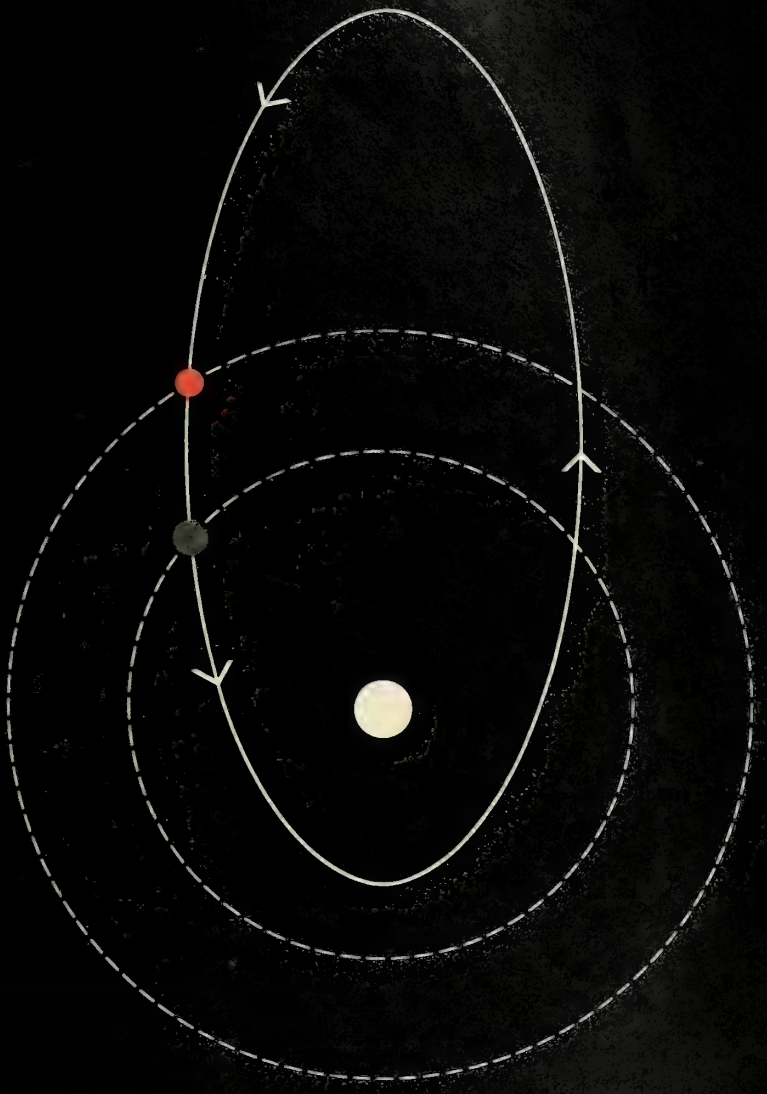
PRESENT LEM WORK

As part of the current work on LEM (Lunar Excursion Module) and lunar exploration vehicles, two huge LEM simulators are now in operation at Grumman—one for lunar landing and one for rendezvousing with the Apollo Command Module. All NASA astronauts have already been indoctrinated on these simulators and are currently rehearsing for actual landing and rendezvous.

ADVANCED SPACE MISSIONS

Many logical extensions of the LEM program are in study phase at Grumman. Current projects involve post LEM lunar exploration, scientific and logistics establishment of lunar bases. Other advanced space work at Grumman includes military vehicles, space research centers, repair service and planet launch platforms.

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MARS MISSIONS

Before manned Mars landings can be accomplished, a wide variety of knowledge must be obtained through probes, orbiters, and hard and soft landers for proper exploration of the planet and its environment. Grumman is doing basic work on such projects for televised examination of permanent and transient surface markings, and analysis of ambient atmospheric conditions on Mars. Under study are vehicles for Mars orbiting and landing.

ORBITAL SPACE STATIONS

Feasibility of interplanetary staging bases has long captured the imagination of space scientists and engineers. The ultimate mechanics of such strategic bases are undergoing prolonged and careful scrutiny at Grumman. Experience gained from the LEM program will vastly enhance the possibility of success in these studies.

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TD 8507

High resolution, separate mesh vidicon. Has same photoconductive coating as the TD 8484, therefore also provides high sensitivity, excellent uniformity and is resistant to burn-in.



TD 1337

Hybrid Industrial Vidicon featuring electrostatic focus and magnetic deflection. Has same high sensitive characteristics as TD 8484, and center resolution in excess of 700 lines.



GEC SPECIAL TUBES

TD 7522

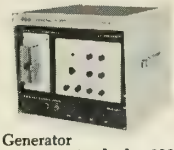
Electrostatic focus and deflection vidicon. High resolution of approximately 600 lines.

TD 1372

A dual gun storage tube capable of simultaneous reading and writing. Over-all construction permits extremely accurate alignment of both guns.



Slow scan television systems
Scan conversion systems
Special purpose test equipment



ED 6025

Slide Video Generator

Completely transistorized, the 6025 is designed to provide video signals by scanning 35 mm slides. Various scanning formats can be obtained by selecting the appropriate plug-in module.

ED 6021

Universal Scan Converter



This completely solid state system is capable of converting between various scan formats. Typical conversions include: PPI to TV, slow scan to TV, character writing input to TV output simply by selecting proper module. The system can be modified to any specific customer requirement. It is designed around the TD 1372 dual gun tube.



ED 6038

Transistorized Environmental TV Camera

Its miniature and rugged design provides for high detail, stable pictures under the severest vibration, shock and noise conditions of missile and space vehicle environments. The system was designed around the GEC ½" Hybrid Vidicon.

ED 6030

Slow Scan TV System

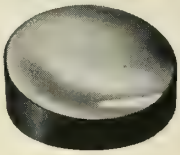


Completely transistorized, the ED 6030 consists of camera head, camera control, monitor and power supply. The system provides continuously variable control of the scanning frequency over a range of 100:1.

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Optical systems
Optics for electronics



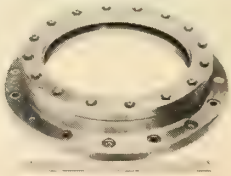
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DOUGLAS CONCEPT of a Manned Orbiting Research Laboratory being studied under a NASA contract.

Part I
NASA PROGRAMS

Request Set at $5.5-5.6 Billion; Spending May Top That in FY '66

Agency officials say figure would be satisfactory plateau for rest of decade; Administration opposition anticipated

FOR THE FIRST TIME in its history, NASA's total expenditures in Fiscal Year 1966 will top its obligational authority.

While the final total will not be known until Congress completes action on the budget, total spending in the next Fiscal Year could be as high as $5.7 billion, a NASA official reports.

The space agency has asked the Bureau of the Budget to approve new obligational authority of $5.5-5.6 billion. It sees this level as a desired plateau at which the budget should run through the rest of this decade.

● **Storm clouds**—Thus far, according to Associate Administrator Dr. Robert C. Seamans, Jr., there has been no assurance from the Administration that it will be approved. Rather, informed sources report, the Administration wants NASA to hold its budget at about the $5.4-billion level in FY '66.

And while the news that total expenditures will top authorized programs is good news for American industry, it has had a bad effect on the prospects for approval of the agency budget.

President Johnson, in his decision to keep Federal funding below $100 billion, has informed his agency heads that they should use the knife just as stringently on expenditures as they do on new obligation authority. Since NASA expenditures will run high next year because of programs authorized in previous Fiscal Years, one way to reduce spending is to put a tight rein on authorizing new programs.

The space agency declares that it needs to increase its budget above last year's $5.35-billion request in order to follow through on present programs such as *Apollo*, and also to take advantage of advancing technology to increase the U.S. space program capability.

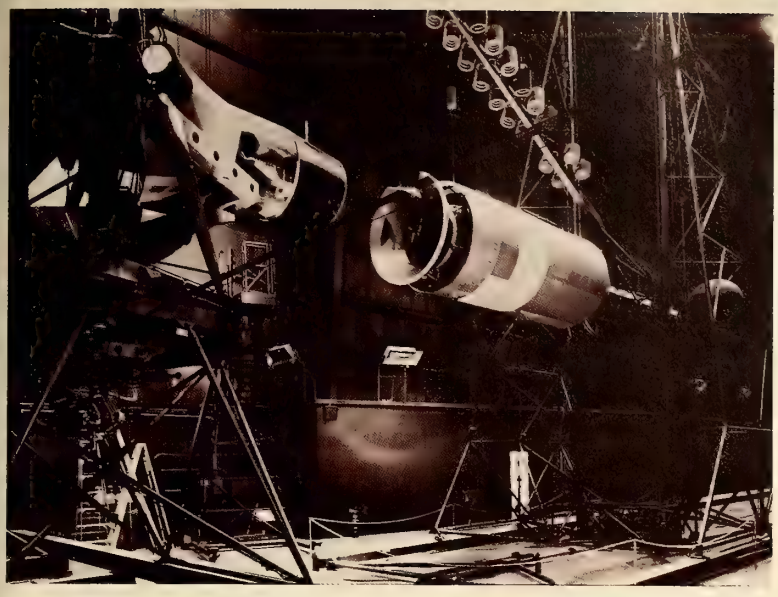
● **What it means**—The $5.5-5.6-billion level in FY '66, according to Seamans, would:

—Permit the *Apollo* Extension Systems (*Apollo-X*) to move to program definition and fund long-leadtime hardware items in FY '66. Another NASA official put this funding level at $50-75 million, but this could prove optimistic. Total cost of the program could be $600 million.

—Not provide funding for a 1969 *Voyager* mission to Mars. There will be funding for a 1971 mission and the project will go to program definition late this year. A prime contractor will be selected in FY '66. Total cost of four spacecraft for two launch windows early in the 1970's is estimated at $1 billion.

Extended Apollo Spacecraft

CONFIGURATION	CHANGES REQUIRED	SUBSYSTEMS AFFECTED	TECHNICAL APPROACH
CSM II MOD + LEM MOD (EARTH & LUNAR)	Increase lifetime to one month	**CSM**	**CSM**
		Electrical power	Electrical power system: Provide in-space start, improve reactant tank insulation
	Install experiments	Life support	Logistics service system: Change to two-gas system, add expendables, food
			Experiments: SM sector I available
		LEM	**LEM**
		Electrical power	Electrical power system: Add fuel cells and reactants improve reactant tank insulation
		Life support	Logistics service system: Add LiOH expendables, food
		Propulsion	Propulsion: Remove ascent propulsion (For shelter and orbital laboratory)
		Structure	Structure: Augment thermal and meteoroid protection
			Experiments: Installed in or outside LEM
CSM II MOD + LEM MOD EARTH ONLY)	Increase lifetime to two-three months	**CSM**	**CSM**
		Propulsion	Service power system: Valve redesign or solids remove one oxidizer and one fuel tank
	Install experiments	Electrical power	Electrical power system: Add fuel cells and reactants (backup development of radioisotope system)
		Life support	Logistics service system: Change to two-gas system, add LiOH expendables, food (backup development of molecular sieve)
			Experiments: Use three empty sectors for experiments and additional power, and expendables
		LEM	**LEM**
		Same as above	Same as above except remove landing gear



FACILITY ENABLES astronauts to simulate rendezvous of two-man Gemini capsule (left) with Agena spacecraft. Walls are coated with black vinyl to simulate space.

—Not include funds for flight tests of a nuclear engine. The only requirement for a nuclear stage is the Manned Mars Exploration program and as the agency general manager sees it, this is still far down the road.

—Provide funding for a start on the *Saturn IB-Centaur* booster which will be used to launch the *Voyager* spacecraft on its early missions.

—Permit modifications to the Lunar Excursion Module to extend its capability in supporting *Apollo-X* as well as lunar exploration staytime. This would involve removal of the ascent propulsion stage. This could be used for storing experiments or additional expendables for *Apollo-X* missions as well as serving as a shelter and storage area for expendables when it is landed unmanned on the Moon.

NASA's budget is usually finalized in mid- to late December. Seamans declared that if the budget is cut, his agency, in its effort to run a balanced program, will spread the reduction fairly equally through its various programs.

As far as a space-station program is concerned, Dr. Seamans said there does not appear to be any reason to make a decision on its configuration for at least one year and probably two.

He said that even if the agency's hoped-for plateau-level budget is approved in FY '66, it will contain only funds to continue to study concepts. He said it would not be initiated in FY '67 unless there was an increase in the budget. The feeling among most Office of Manned Spaceflight officials is that the space-station program will not get an early start unless President Johnson decides to make it his own personally initiated space program and gives the go-ahead for heavy funding.

● **Breakdown**—The increase in NASA's request for the next fiscal period results from increased costs in the agency's *Apollo* program as well as its failure to get Congressional approval for its FY '65 supplemental request.

One official told MISSILES & ROCKETS that Manned Spaceflight research and development funding in FY '66 will be about $3.3-3.4 billion. If the Administration or Congress cuts the overall budget request to $5.4 billion, manned spaceflight R&D would be reduced by an overall $100 million.

Administration operations funding will run at about a $250-million level. The construction budget will continue to fall as it did in FY '65, reaching only $50 million in FY '66.

Project *Gemini*—the two-man spaceflight series scheduled to make its first manned flight early next year—will be funded at a level of about $200 million. This will be split just about equally between the spacecraft development and the two launch vehicles in the program, the *Titan II* and the *Atlas-Agena*.

Advanced missions study funding will remain at about the FY '65 level—some $26 million.

Funding of the *Apollo* spacecraft will run between $1.1 and $1.2 billion dollars. Even if the Administration reduces the overall budget, this portion should remain relatively untouched as the agency drives to meet its goal of landing a man on the Moon before the end of this decade.

Launch vehicle funding will be approximately $1.3-1.4 billion. About two thirds will be used for the *Saturn V* booster, with the remainder slated for the *Saturn IB*. Continued development of the F-1 and J-2 engines will be funded at the $100-million level.

Remainder of the total request will be split up, with about $300 million for the Office of Advanced Research and Technology and $800 million for the Office of Space Sciences and Applications.

● **Long shots**—Seamans said that there appears to be only a slight chance that the 1969 *Voyager* mission will be funded. He said this would hold true even if the budget reached the $5.5-5.6-billion level.

He also declared that it would not be replaced by an *Advanced Mariner* type of spacecraft.

"Representatives of the scientific community would like to make a launch in that period and so would I. Some people have told us that if we can't support a *Voyager* mission we should move to an *Atlas-Centaur*-class flight. When you look at such a mission, you find that you are only splitting your limited resources. My view is that we should concentrate on development of the *Voyager*."

He added that an *Atlas-Centaur/Advanced Mariner* mission would not provide the kind of scientific information that the Space Science Board of the National Academy of Sciences wants to get about Mars.

As for the nuclear engine flight-testing, he said that while the R&D program has chalked up some significant recent successes, this does not mean a go-ahead for the project.

"A year ago, NASA and the AEC set up a two-year development program and it is nice to see it moving along," he continued. He declined to say when flight-testing might be funded, but he did rule it out for FY '66.

While NASA is pushing for a $5.5-$5.6-billion total, and hoping to get as much as $5.4 billion, one Johnson Administration official predicted that the total might be closer to $5 billion than $5.5 billion.

"President Johnson is eager to keep next year's budget down. While NASA may want up to $5.6 billion, they just are not going to get it," the official said.

As far as the space station is concerned, the official said he agreed with Dr. Seamans that it was too early to make a decision on its configuration or give it a go-ahead.

"We haven't any real long-orbital-flight experience, nor have we accomplished a rendezvous maneuver in space. We are going to have experience in both before we embark on a six to 12-man space station." (*See table, p. 46.*) ■

Beyond Apollo: The U.S. Space Program

PROJECT	MISSION	FLIGHT SCHEDULE	STATUS	FUNDING
Apollo-X	Manned long-duration flights in various orbits	1969-71	Program definition in FY '66	1966
Extended Lunar Exploration	Increase stay-time on lunar surface, perhaps to 90 days	1971 (at earliest)	Decision on configuration in 12 to 15 months	1966
Space Station	Manned long-duration missions for periods of a year or more	1972-73	Study	Program Definition 1967-68
Manned Mars (Manned Interplanetary)	Manned orbiting and landing on Mars	1985 (at earliest)	Study phases only	1967
Post-Saturn Launch Vehicle	Earth Orbital, Manned Interplanetary	Undetermined but based on Earth-orbital departure	Study phases only	1967
Voyager	Unmanned planetary exploration	1969—earliest possible flight (Voyager Test Vehicle) 1971—1st Bus/Lander system	RFP's to be issued in December, 1964; development to begin in late 1965 or early 1966	1965
Radio Astronomy Explorer	Mapping of the universe in wavelengths below 3,000 mc.	1967	Expected to be approved this year	1965
Saturn 1B-Centaur	Booster for Voyager spacecraft	1969 or 1971	R&D in FY '66	1966
Extended Pioneer	Probe to within 0.05 au of Sun	1968-71	R&D in FY '66	1966
Advanced Pioneer	To serve as first solar monitor	1972-79	Study	1968
Space Cruiser	Deliver 500 lbs. of instruments anywhere	Late in next decade	Study	1970's
Engineering Test Satellite	Test bed for research & technology programs	Late in this decade	Study; funding expected in FY '66	Development funds, 1967
Orbital Scanner	Small satellite for long-duration horizon scanning	Not known	Study	Not known
(Weather Bureau) Tiros Operational System	Daily global weather information	1966	Approved for launch in pairs so that two are in orbit at all times	1965
Advanced Satellite System	To give operational day and night cloud pictures and other advanced measurements	Not before 1970	Weather Bureau's requirements being worked out for presentation to NASA sometime next year	Some experiments leading to development of technology, FY '66. No full systems until after 1970
(A.E.C.) Rover	Nuclear rocket propulsion systems	Not before early 1970's (NERVA); late 1970's (Phoebus)	Developing reactor and engine technology and primarily reactor development	1965 (NERVA) 1966 (Phoebus I)
SNAP-50/SPUR	Power source for space electric propulsion system and auxiliary power	Not before 1975	Developing 300-1,000 kwe reactor and energy conversion system	1965
(COMSAT) Early Bird (HS-303)	Experimental/ operational synchronous orbit system	March, 1965, 1st satellite	Development	$8 million to Hughes in March, 1964
Operational Communications Satellite System	Global communications system using medium- or synchronous-altitude systems or a mixture of both	1st launching in late 1966; operational system complete in late 1967	Research and development	Development effort to start in early 1965

Space Agency Consolidating Contract Administration Under National Plan

Project 60 is first step in preventing duplication of effort; agency aims for $1 billion in incentives by end of FY '65

COOPERATION with the Defense Department in a nationwide system of consolidated contract administration is expected to significantly refine NASA procurement within the next 18 months. The move, coupled with intensive emphasis on incentives, will bring the space agency tighter control over its suppliers.

A pilot test of the new DOD/NASA contract administration system was inaugurated April 20, with the Defense Supply Agency's Philadelphia region as headquarters. The region encompasses most of Pennsylvania, the southern counties of New Jersey, and all of Virginia, Maryland, West Virginia and the District of Columbia.

Both Defense and space agency officials are enthusiastic about the experience gained from this pilot-test region—designated Project 60 by DOD. Some 12,000 contracts are in effect in the Philadelphia pilot region, of which 201 with a value of more than $235 million are NASA contracts.

The pilot test has already shown that DOD personnel can effectively administer NASA contracts in the field, on a reimbursable basis, at a considerable saving of personnel and expense to the space agency, and without undue burden to DOD. Nor will the program cause any cutbacks in NASA personnel.

PROJECT 60

A DOD spokesman says there are approximately 2,050 persons on the DOD payroll in the Philadelphia pilot region, and "very few" NASA employees involved in contract administration.

While NASA would not need as many personnel as DOD to monitor its contracts in the pilot-test area, participation in the project has saved NASA considerable duplication in personnel.

Indeed, the agreement between DOD and NASA establishing cooperation in Project 60 states that its intention is "to avoid, to the maximum extent, duplication of effort and to achieve the most effective and economical utilization of Department of Defense and NASA resources in the performance of contract administration services in support of NASA."

● **Evolution**—Project 60 was not initiated for the convenience of the space agency. It was conceived in 1962 to make Defense procurement more efficient. A DOD policy committee was established at that time to report to Defense Secretary Robert S. McNamara on the feasibility of centralizing DOD contract administration.

McNamara invited NASA Administrator James E. Webb to participate in Project 60 so that the space agency might profit from DOD's experience in streamlining contract administration.

The Philadelphia pilot-test experience portends extensive advantages to both DOD and NASA. All Army, Navy, Air Force and NASA field contracting offices and personnel have been brought under one roof and are administered by the Defense Supply Agency.

One illustration of the system's potential is the savings in paperwork ushered in by Project 60 in the pre-award phases of contracting. Before Project 60, a contractor hoping to compete for an award had to complete a capability survey (possibly for more than one of the services) that might be 31 pages long. There is now a single capability survey form no more than 11 pages long.

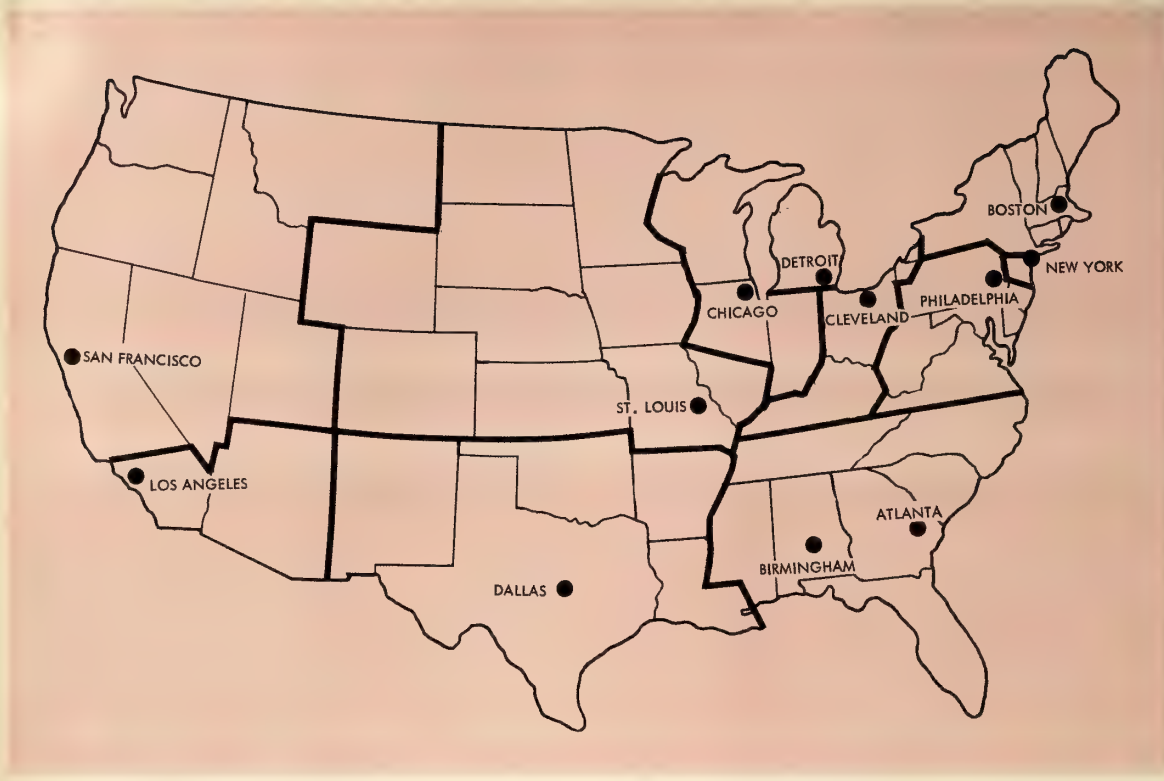
Project 60 is an interim undertaking conducted under a National Planning Group for Contract Administration Services. It is currently headed by Air Force Maj. Gen. William Veal of the Defense Supply Agency at Cameron



ERNEST W. BRACKETT, assistant deputy associate administrator, procurement policy.



GEORGE J. VECCHIETTI, director of NASA's office of procurement.



ELEVEN PROPOSED regions for consolidated national contract administration plan.

Station, Alexandria, Va.

● **The national plan**—The planning group's outline for an 11-region nationwide system (see accompanying map) will go to Secretary McNamara Jan. 1. It will call for consolidation of all military and NASA contract administration services in the 11 regions 18 months after Secretary McNamara approves the plan. One DOD official, however, says those close to the program thought implementation could be brought about sooner.

When consolidation is complete (some is already under way, in addition to the pilot effort), a deputy director for contract administration services in the Defense Supply Agency will head the permanent program. In addition to Philadelphia, these cities will be the other regional headquarters: Boston, New York, Cleveland, Atlanta or Birmingham, Ala., Detroit, Chicago, St. Louis, Dallas, San Francisco and Los Angeles.

Defense officials say the next region being considered for consolidation is that centered in Detroit. April 1, 1965, is the target date for consolidation.

California, with its vast aerospace industry, should illustrate the economies promised by consolidating all military and NASA contract administration in one agency. There are now almost 6,000 persons in California engaged in procurement activities, of whom 179 are NASA personnel, including those staffing the Western Operations Office in Santa Monica. California firms hold NASA contracts with face values totaling between $12 billion and $15 billion.

If DOD personnel did not administer NASA contracts in the region, the additional expense to NASA in increased personnel, greater office space and such costs as relocation of personnel from other areas would press the space agency budget unnecessarily. In Southern California alone, some 230 Air Force personnel are engaged exclusively in NASA contract administration.

● **Step-by-step**—The DOD/NASA agreement spells out in detail what DOD personnel are to do in support of NASA, (presumably the National Planning Group will recommend the same arrangement when the system goes national):

1) *Contract administration*—acceptance of costs, approval of contractors' systems, subcontract and purchase-order approval and consent, price and cost analysis, and related assistance before and during negotiations.

2) *Terminations*—negotiation of settlements of contracts terminated for convenience.

3) *Plant clearance*—disposal of excess government property in possession of contractors.

4) *Property administration*—determination of liability for loss or damage.

5) *Quality assurance*—inspection and/or acceptance of supplies and services, review of contractors' inspection and/or quality control programs, and defining quality characteristics not previously determined. This area accounts for the greatest concentration of personnel—40%—of any of the functional areas outlined here.

6) *Production and industrial resources*—production support and surveillance, pre-award surveys and priority and allocation systems.

7) *Industrial manpower*—as requested by the buying activity.

8) *Engineering liaison*—as requested by the buying activity.

9) *Transportation*—issue and control of governments bills of lading.

10) *Industrial security*—to perform as the cognizant industrial security office.

11) *Financial management*—the contract administration element of the pilot-test region (Philadelphia) will obtain and forward contractors' financial management status reports.

12) *Small business and labor surplus*—assistance to small business firms and contractors located in labor surplus areas.

13) *Safety*—safety matters on nonhazardous materials and processes.

14) *Performance* of any additional

functions as agreed between the purchasing office and the (Philadelphia) test director.

NASA reimbursement of DOD for contract administration services performed in the Philadelphia pilot-test region is detailed in a memorandum of understanding that supplements the agreement establishing cooperation in the pilot program.

● **The negative reaction**—Although pilot-test region results encourage defense and space agency officials to proceed with the nationwide consolidation of contract administration services, industry response hasn't all been favorable.

Painstaking explanation of the program's objectives has been required in the Philadelphia region when any of the services has informed a "landlord" it is vacating its premises to consolidate procurement functions at the Defense Supply Agency facility there.

Similarly, incentive contracting is "no panacea" that will protect the space agency from cost overruns or program slippages, but Ernest W. Brackett, Assistant Deputy Administrator for Procurement Policy, says NASA will be continually looking to see if incentives can be applied in all new procurement.

INCENTIVES

Study contracts don't always lend themselves to incentives, Brackett says, in which case fixed-price contracts—"the strongest incentive there is"—usually apply.

But the explosive growth in application of incentive contracting that has typified space agency procurement for the past two years will continue, NASA officials feel.

Two years ago, NASA had only two contracts with any incentive provisions in effect. The figure jumped to 17 by November, 1963, and now stands at 60. NASA incentive contracts in force have a face value of more than $650 million. The space agency's goal is to boost that figure to $1 billion by the end of Fiscal Year 1965.

● **Pioneering pains**—The agency's earlier cost-plus-fixed-fee procurement policy stemmed from the fact that there was little or no precedent for the work being done: "Nobody had ever made a three-man capsule to go to the Moon before," says Brackett.

In addition to this factor, the kind of procurement peculiar to NASA—the purchase of few-of-a-kind items—encouraged the earlier reliance on fixed-fee contracting until a history of contractor performance could be generated that might provide reasonable expectations as to cost, delivery and quality of the item.

The ideal incentive contract, say Brackett and George J. Vecchietti, Director of NASA's Procurement Office, is the cost-plus-incentive-fee (CPIF) type that promises the contractor incentive fees for remaining within negotiated costs and early or on-time delivery of a product that performs at least as well as NASA specifications require.

Of the 60 incentive contracts in force, 31 are in the CPIF category, 13 are fixed-price-incentives (FPI) and 10 are cost-plus-award-fee (CPAF). The remainder are combinations to which incentives of some type have been applied.

The space agency does make volume purchases of some items, launch vehicles among them. In such instances, where quantity purchasing is possible and extensive production history exists, it is also attempting to convert to incentives or apply incentives to follow-on contracts.

The first such conversion involved a contract with Ling-Temco-Vought, Inc. —a follow-on order for 23 *Scout* boosters. Originally a cost-plus-fixed-fee (CPFF) contract, it has been renegotiated as a fixed-price-incentive (FPI) type.

Another big-dollar contract being renegotiated from CPFF to CPIF is that with McDonnell Aircraft Corp. for the two-man *Gemini* capsule. There is no present plan to convert the *Apollo* spacecraft CPFF contract with North American Aviation, Inc., to incentives, but "the possibility exists," say procurement officials.

● **Competition intensified**—The space agency is also continuing to encourage contract negotiation in a competitive atmosphere to "shake down" the field of bidders on a particular request for proposals, reducing their number to those firms most likely to be capable of delivering a quality product on time and without cost overruns.

NASA's source-selection board sets in motion the machinery to create a highly competitive atmosphere. Any contract worth more than $5 million must be reviewed by the source-selection board at NASA headquarters. The board issues RFP's after being informed of their need by the cognizant program office at headquarters.

The board issues the RFP's and, after bids are received from industry, they are reviewed by the board-appointed business and technical committee. The committee reports its findings on the bids to the source-selection board, which in turn presents the committee's findings to Administrator Webb and Associate Administrator Dr. Robert C. Seamans.

The firms most likely to win the awards are indicated at this time, and "hard-nosed" negotiations begin, with those firms still in the running informed that they are competing with companies "A" and "B."

In this manner, the space agency can trim much of the "fat" out of its contracts.

● **Keeping subs competitive**—NASA likes to stress competition among the myriad subcontractors on a particular program. Although the agency does not select subcontractors (who currently receive 50% of NASA contracts), it does have an approval prerogative that can be exercised in the field.

Contracting officials in the field have the power to veto a potential subcontractor if his share exceeds $25,000, and this intensifies realistic bidding all down the line. Agency officials say, however, that this veto option has been exercised very seldom.

The space agency also keeps tabs on its primes by sending a representative with DOD's purchasing survey team into any plant holding $25 million in NASA contracts. This serves as a check on how well the prime is managing his subcontractors.

And a recently adopted procedure further assists NASA Headquarters in assessing contractor performance. Each field center files a monthly report to Headquarters detailing how well each of its incentive contractors appears to be meeting the requirements of the contract.

Another procurement procedure that has cut NASA costs is its adoption of a uniform relocation cost regulation. Most firms have differing plans for reimbursing employees who have to relocate to go to work on a new contract, and NASA at first tried to follow the plan of the firm with which it contracted.

There was too wide a divergence, however, and the space agency has standardized the costs it will pay for relocating contractor personnel. NASA officials feel that their standardized plan is equitable, but they also report some grumbling from employees of firms whose relocation allowances are more liberal than NASA's.

● **Assisting industry**—A summary of other moves NASA has made to assist firms interested in selling to it shows the agency has:

—Published a volume entitled "NASA Procurement Regulations," which can be purchased at the Government Printing Office in Washington.

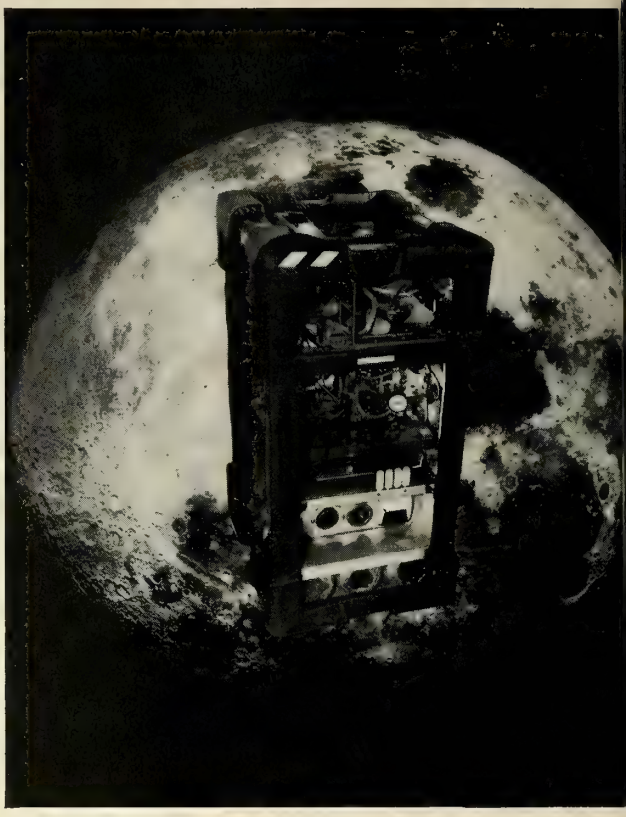
—Published a manual (not for sale) explaining source-selection philosophy and procedures.

—Inaugurated DOD's contractor performance evaluation system on a trial basis. A group at each field center is applying the system to one contractor and reporting to an *ad hoc* committee at NASA Headquarters. The system has been in effect only about a year, but promises to weed out poor performers even though it still is far from a perfect tool. ■

Another fuel cell application/success report from Allis-Chalmers:



FIRST... in a land vehicle, a 15-kw tractor... 1959.



FIRST... to successfully pass zero gravity tests, Wright Patterson AFB... 1962.

Allis-Chalmers points the way

1959, A-C built a self-contained 15-kw fuel cell-powered tractor — the first application of fuel cells to terrestrial vehicles.

In 1962, A-C demonstrated another fuel cell first. In cooperation with the U. S. Air Force, A-C successfully zero-gravity-tested a fuel cell power pack.

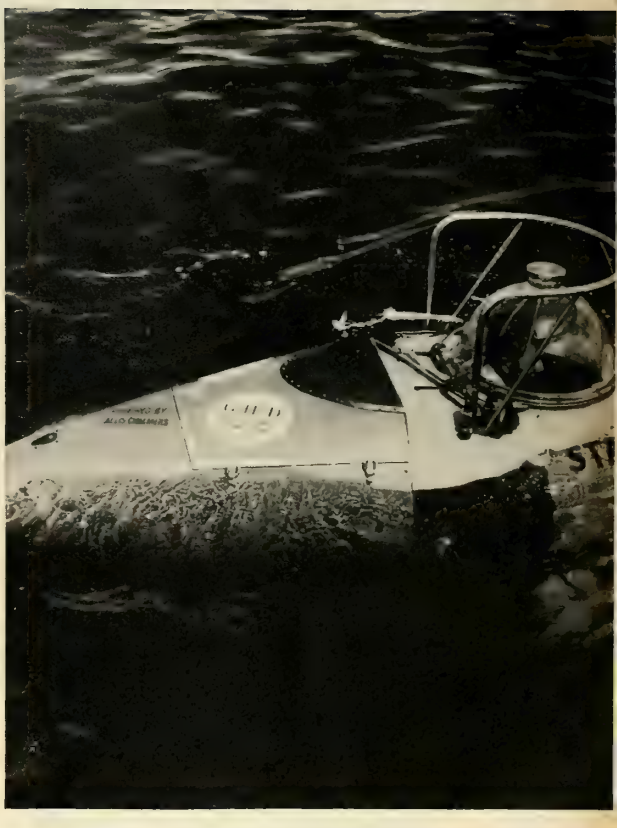
In March, 1964, A-C created another fuel cell first by building and testing for the air force, the first fuel-cell power pack qualified for orbit. This 14-lb., 50-watt H_2O_2 fuel cell proved the reliability of Allis-Chalmers fuel cells under some of man's most stringent tests.

In July, 1964, A-C scored another fuel cell first. We delivered fuel cell power to General Dynamic's/Electric Boat — Star I submarine. This hydrazine-oxygen, 36-volt, 750-watt power pack doubled the Star I's endurance. Previously, batteries lasted 4 hours and required 8 hours for recharging. With the fuel cell system, endurance is based only on fuel and oxidant

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FIRST... "qualified for space" fuel cells for the Air Force ... March, 1964.



FIRST... to power an underwater vehicle ... July, 1964.

in applying Fuel Cell power...

supplies aboard. Refueling takes only 5-10 minutes.

We've perfected the static moisture removal concept. Water is removed from the fuel cell system without the use of pumps and intricate auxiliaries.

We've introduced fuel cell catalyst developments such as nickel boride.

We applied multi-kilowatt fuel cell power systems to an experimental golf cart, a lift truck and to other vehicles illustrated above.

This is why Allis-Chalmers believes that it is one thing to research fuel cells and quite another to develop workable units — and then apply them successfully!

May we discuss your aerospace and defense fuel cell application? TELEPHONE AREA CODE 414-774-3600, EXT. 491, ALLIS-CHALMERS box 512, Milwaukee, Wis., 53201.

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Apollo-X Spacecraft Going Into Program Definition Next Fiscal Year

Plans call for flights beginning in 1968-69; no hardware funding for space station expected before Fiscal 1968

MANNED SPACE FLIGHT officials are moving ahead with plans for a post-*Apollo* schedule of 18 missions, with the *Apollo-X* spacecraft carrying experimental payloads estimated to cost up to $600 million.

The same officials now seem to favor a new, single-structure spacecraft weighing about 30,000 lbs. as the first true NASA space station, with flights to begin in the 1972-73 period. As one official put it, "If we had to go today, this is the way we would go."

This would appear to downgrade the Manned Spacecraft Center proposal to add modules to the *Apollo* spacecraft and then join three of them together into a "Y"-shaped station capable of holding up to 36 astronauts.

Dr. Robert C. Seamans, Jr., associate administrator, told MISSILES & ROCKETS, however, that "since no decision is required on the space station configuration for at least one year and possibly two, we will continue to study all concepts."

NASA, however, is definitely moving into the program-definition phase (PDP) of the *Apollo Extension Systems* (*Apollo-X*) in the next fiscal year.

Plans also call for some funding of long lead-time systems; however, this is based on Johnson Administration approval of a $5.6-billion budget, which would provide about $50 to $75 million for *Apollo-X*. If the budget—as expected—drops to the $5.4-5.5-billion level, the program will still go to program definition, but the flight schedule would be delayed for as much as a year.

NASA's current plan is to begin flights of the *Apollo-X* in late 1968 or early 1969 with missions continuing into 1971. In late 1971 or 1972, the Office of Manned Space Flight believes it will be necessary for both technological and economic reasons to go to a six to 12-man space station capable of staying in Earth orbit for a minimum of one year.

● **Space station all new**—While no final decision has been made, Advanced Manned Missions Study officials will probably recommend eventually that the space station should be a new spacecraft using either *Apollo* or *Gemini* spacecraft as supply vehicles. It will be a continuous structure—not modules joined together—weighing from 30,000 to 50,000 lbs. and having a diameter of about 22 ft.

The officials believe that this is just about right for a space station. One scientist said that one of the reasons Headquarters is shying away from the Manned Spacecraft modular space station is that its 15-ft. diameter is considered too thin. A 22-ft.-dia. station will also apparently rule out the *Titan III* as the booster in the program because its diameter at the transtage is only 10 ft.

The Manned Space Flight Office plans now call for going into the preprogram definition phase in the next fiscal year with PDP and hardware funding of long lead-time items in FY '67. This may be an optimistic schedule and slippage of a year is possible.

For the present, the space station program will remain at the Langley Research Center. It will be placed under the management of the Manned Spacecraft Center sometime in the next fiscal year.

● **Apollo-X**—One of the big unanswered questions in the *Apollo-X* program is how big a role North American Aviation's Space & Information Systems Div.—prime contractor for the *Apollo* Command and Service Modules —will play in it.

Serious consideration is being given to selecting another firm to take basic *Apollo* capsules produced by North American and the Lunar Excursion Modules (LEM) produced by Grumman Aircraft Engineering Corp. and modify them for *Apollo-X* missions.

The major modifications include removal of the LEM ascent stage propulsion which would allow 1,300 cu. ft. for experiments and for long Earth-orbital flights; two Service Module propulsion tanks would also be removed.

In terms of subsystems, the main modifications would be made to the power system and the environmental controls system, which will be changed to a two-gas system. NASA estimated the total cost of the modifications at under $100 million.

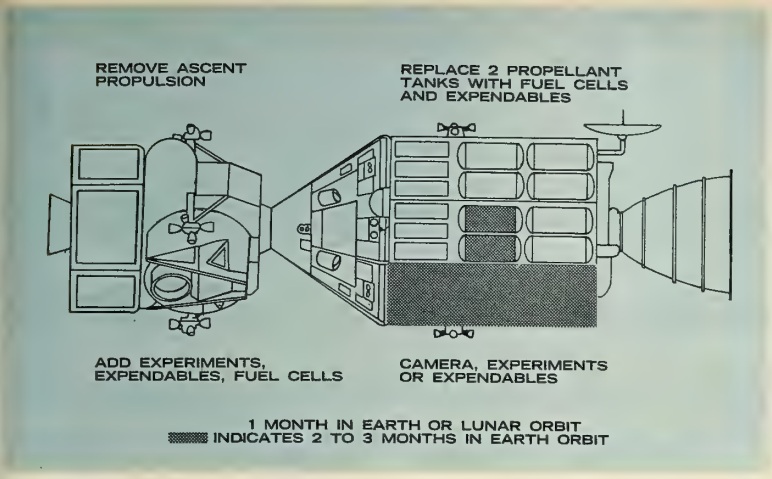
The really booming market for industry will be in supplying the instrumentation and systems for the experiments that will ride on *Apollo-X*.

Since the program has not been finalized, manned spaceflight officials can only estimate that the experimental payloads will cost between $300 and $600 million. They will be centered in such areas as meteorology, mapping and survey, research and technology, lunar surface exploration, lunar orbital study, astronomy, communications, biomedical and behavioral research and operations capability.

Details of the experiments, number of flights, required instruments and systems are included in a specially prepared M/R table on page 56. The ground rules for *Apollo-X* dictate a minimum change.

● **Design studies under way**—North American—as prime contractor on *Apollo*—is conducting a preliminary design study of *Apollo-X* under a $700,000 contract from the Manned Spacecraft Center. An earlier increment of the study was conducted with about $350,000 provided jointly by NASA and North American. The present contract expires in March, 1965.

The cubage and weight allowance



APOLLO-X CONCEPT. Shaded areas indicate extra expendables for long trips.

for the extra expendables such as fuel, cabin air and food for the 28 or 30-day missions becomes available with the elimination of some of the more stringent lunar mission requirements. Removal of the Lunar Excursion Module from its adapter atop a *Saturn V* provides ample volume and a 32,000-lb. weight allowance for very-long-duration lab modules.

Saturn IB is a more likely choice for the more limited *Apollo-X* goals because of its lower cost and earlier availability. Between 1,000 and 2,000 lbs. can be made available for Earth-orbital missions by machining the heat shield thinner, since entry velocities will be on the order of 25,000 fps rather than 35,000 fps. More weight can be saved by removing navigational and experimental equipment needed only for the lunar mission.

Apollo-X may carry three men or two; the decision has not been made. Eliminating one man provides a handsome return in weight and cubage. His absence would reduce the rate at which expendables are consumed and would provide more storage space or work space for lab tasks.

The Russian achievement of three-man orbital flight robs two-man missions of much of their propaganda charm and may make it impossible to judge this question on a purely technical basis.

● **Abort and life-support**—The sheer distances and times involved in lunar *Apollo* missions has demanded severe abort criteria. Relaxation of these because of the relative ease with which an Earth-orbit mission can be aborted does much to give *Apollo-X* its extended duration.

For instance, on a lunar mission the failure of even one of the three fuel cell power supplies demands an immediate abort because the failure of one more cell would mean that a full-duration mission could not be completed without the loss of on-board power and the death of the astronauts.

The third cell, which is an emergency back-up for lunar missions, can be expended as part of the primary system in Earth orbit, thus adding substantially to mission duration. Setting design criteria for the power system may be a subtle problem because fuel cells appear to deteriorate slowly rather than failing suddenly.

A number of other systems critical to astronaut survival for the full duration of the lunar mission provide a built-in mission extension for Earth orbit.

● **What atmosphere?**—It would be true of the environmental control system supplied by AiResearch Div. of Garrett Corp., except for the fact that there is a tacit consensus among engineers that the switch from a 5-psi pure oxygen system to a 7.5-psi double-gas system will be made on *Apollo-X*.

This would require design of a new system and, in view of the "minimum change" requirement imposed on *Apollo-X*, it may have a strong bearing on the future prospects of the program.

NAA engineers are still thinking of the new atmosphere as a nitrogen-oxygen mixture. AiResearch, however, is studying helium and oxygen. Navy submarine development has shown that this mixture would reduce the danger of the bends in the transition from the cabin atmosphere to a 5-psi oxygen environment in an extra-vehicular spacesuit.

Preliminary results of the AiResearch work, under the direction of Dr. James Waggoner, indicate there may be other advantages to the mixture. The maximum comfort temperature level in helium-oxygen appears to be about 6°F higher than in pure oxygen. This would simplify the problem of temperature

Research and Technology Requirements for MORL

I. LONG LEADTIME DEVELOPMENT AND TESTING

Subsystem Development

- Assessment of compatibility of spacesuit developments with MORL atmosphere.
- Qualification of air evaporation/humidity water-processing system proposed for MORL.
- Development and qualification of zero-g galley and laundry equipment.
- Design and qualification of an adequate logistics system, including (1) requirements for long-term ferry vehicle storage, (2) cryogenic and propellant handling methods and criteria, and (3) packaged cargo handling methods and criteria.
- Development and qualification of the various mechanisms involved in operation of MORL including (1) docking and stowage arms, (2) experimental and operational handling arms, (3) airlock operating and sealing mechanisms, (4) centrifuge and its control and balance, (5) solar panel deployment mechanism, and (6) spin deployment and retraction mechanism.
- Development and qualification of control-moment gyro system sized to MORL-class requirements.
- Determination of hypergolic propellant long-term storage and ignition characteristics under orbital environment conditions.
- Qualification of long-life engines (10,000 + seconds) for use in orbit-keeping and attitude control.
- Development of long-life bellows (1,000 + cycles) capable of storing hypergolic propellants for extended periods.
- Assessment and/or development and qualification of Isotope/Brayton power generation equipment for MORL.
- Development and qualification of a low-loss, high-power rf switch for use at S-band frequencies.
- Development of experimental equipment.

Human Compatibility

- Determination of physiological/psychological monitoring and conditioning criteria.
- Qualification of the proposed MORL atmosphere for long-term habitability.
- Determination of detrimental atmospheric and water trace contaminents, toxicity levels, and methods of control.
- Assessment of long-term exposure to modified (semisterile) bacteriological environment.
- Assessment and optimization of the proposed Apollo/MORL rendezvous and docking methods.
- Assessment of man's capability in zero-g to perform station-keeping operations, maintenance and experimentation. Further assessment of man's response to rotating environments.
- Estimation of man's capability in extravehicular activities requiring spacesuit operations.

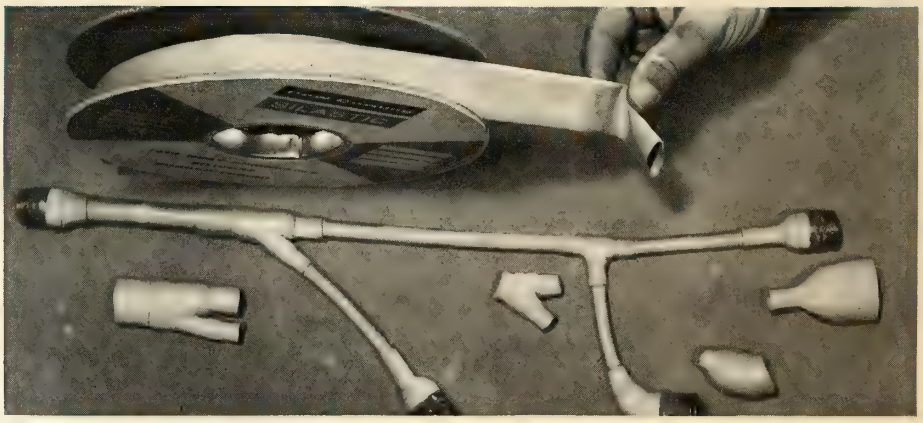
Design Criteria Development

- Determination of radiation environment in all areas of mission interest.
- Determination of micrometeoroid environment in all areas of mission interest.
- Determination of the effects of ultra-high vacuum on material properties and material processing and handling.
- Establishment of realistic long-term radiation exposure criteria for man.
- Establishment of requirements and operational parameters for spinning operation of the MORL.

II. SECOND-GENERATION DEVELOPMENT REQUIREMENTS

- With MORL as test vehicle—
  1. Development of detail criteria to monitor and maintain man's physiological and psychological fitness.
  2. Development of detail criteria for man's performance under zero-g in both spacesuit and shirtsleeve operations.
  3. Ultra-high vacuum effects on materials, finishes, etc.
  4. Development of processing, handling, repair, and assembly techniques.
- Development and qualification aboard MORL of an optimum O_2 regeneration system.
- Assessment of use of other CO_2 absorption systems.
- Assessment of the relative economic effectiveness of an electrodialysis/air evaporation urine purification system for long-term space station operations.
- Development of reliable slip rings to allow use of more efficient (propellent expenditure) orientations during spinning operations.
- Development and qualification of nuclear power generation systems.
- Development of data compaction methods suitable for on-board use.
- Development of experimental equipment.

News Briefs



A new heat-shrinkable silicone rubber, supplied in the form of finished parts by Dow Corning, shrinks to one-half its original diameter when heated briefly at 300F. Silastic® 1410 heat-shrinkable rubber provides tight, form-fitting protection for wire harnesses, cable splices, miliconductor cables, hydraulic and mechanical couplings, or acts as cable blast shields in rocket launching applications. After shrinking, this material retains its flexibility from —100 to 500 F. Available in a range of stock tubing sizes or as custom made parts of varying shapes.

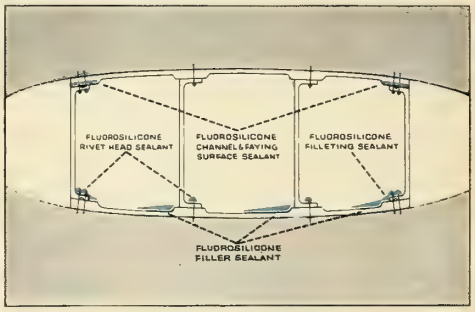
CIRCLE 22 ON READER SERVICE CARD

New fluorosilicone rubber sealants seal integral fuel tanks on F-111

A new family of one-part fluorosilicone rubber sealants, developed by Dow Corning for the aerospace industry is meeting the needs for fuel resistant seals in high performance aircraft. Because of their flexibility and strength while immersed in jet fuel at temperatures from −70 to 500 F, four of these sealants were selected by General Dynamics for use in sealing critical areas of the integral fuel tanks in the F-111 Air Force/Navy tactical fighter.

A special fluorosilicone sealant which air cures to a resilient rubber was developed for use in filleting, another for rivet head and fastener coverings. Low spots that would form natural sumps are filled with a low density fluorosilicone sealant. Finally a *non-curing* sealant was designed for channel and faying surfaces.

The three sealants which cure to a strong rubber retain peel and bond strength after prolonged immersion in jet fuels or when subjected to splash and fume exposure of rocket fuels such as nitrogen tetroxide or hydrazine. All have excellent resistance to ozone, oxygen, many chemicals, weather, aging and thermal cycling. These fuel tank sealants are simply examples of Dow Corning's ability to engineer products for specific aerospace applications.



CIRCLE 21 ON READER SERVICE CARD



New non-corrosive sealants, for aerospace applications, are now available from Dow Corning. These one-component sealants cure at room temperature to tough silicone rubber without liberating acetic acid; therefore are not noxious when used in confined areas. Common aerospace *structural* metals and materials show no corrosive reaction to these new sealants. They can be used for bonding, sealing, encapsulating, and coating surfaces which require heat, age and weather resistance. These sealants are ideal for construction of missiles and rockets as well as for on-site maintenance.

CIRCLE 23 ON READER SERVICE CARD

For further information about materials described here . . . or our capability to provide you with tailor-made materials designed specifically to meet your requirements, write Dept. 6211, or call Aerospace Materials Dept., Dow Corning, Midland, Michigan.

Dow Corning

control, AiResearch engineers point out.

A possible disadvantage is increased leakage caused by higher cabin pressure. The weight penalty charged to this could be a serious obstacle when compounded over a 30- to 90-day mission. It may be offset, however, by reduced pumping requirements that have been indicated in the early AiResearch work. But for the fact that NASA had a thorough understanding of the single-gas system gained in Project *Mercury* and knew relatively little about two-gas systems, it is probable that even the lunar *Apollo* would have gone the two-gas route.

Some components, such as control systems and certain communications experiments, require as much redundancy for either mission and so must be designed up to the new longer mission. The *Apollo-X* study teams are retaining the lunar *Apollo* plan of attempting no repair or replacement of components in flight. This means that where the greater redundancy required by the lunar mission cannot be used to extend mission duration, reliability programs must re-qualify components for longer lifetime.

No decision has been made on how long a mission must be to make an in-flight maintenance more desirable than redundant back-ups. However, it is far beyond the 30- to 90-day missions contemplated in the *Apollo-X* studies. ■

Apollo-X Experiments and Flight Plans

METEOROLOGY

OBJECTIVES: ESTABLISH FEASIBILITY AND USE OF MANNED MULTISENSOR WEATHER SATELLITE

MISSION CHARACTERISTICS: INITIAL EXPERIMENTAL FLIGHTS IN LOW ALTITUDE 30° ORBITS. POLAR ORBITS FOR GLOBAL OBSERVATIONS. SYNCHRONOUS ORBITS FOR SYNOPTIC CONTINUOUS OBSERVATION

EXPERIMENTS: CORRELATED BROAD SPECTRUM EXPERIMENTS USING MULTISPECTRAL CAMERA, IR LINE SCANNING IMAGERY, SIDE LOOKING RADAR (3 FREQUENCIES), SPECTROMETER, SOLAR RADIATION TELESCOPE

LIMITING FACTORS: THREE-FREQUENCY SIDE-LOOKING RADAR FEASIBLE BUT NOT DEVELOPED. LONG DURATION SUBSYSTEMS. DATA HANDLING OPERATIONS PROCEDURES

PROSPECTS FOR SOLUTION: THREE-FREQUENCY RADAR CAN BE DEVELOPED WITHIN 36 MONTHS. NO TECHNICAL BREAKTHROUGH REQUIRED. DEVELOPMENT FUNDING REQUIRED

FLIGHT PROGRAM: SIX FLIGHTS PLANNED. EXPERIMENTS INCLUDE: MULTISPECTRAL CAMERA CHECKED OUT AND OPERATED ON LUNAR SURVEY SIMULATION MISSION IN EARTH-ORBIT INITIAL FAMILIARIZATION; SPECTROMETER FOR MAPPING EARTH RADIATION CHECKED OUT AND OPERATED IN SYNCHRONOUS ORBIT; MULTISPECTRAL CAMERA FLOWN WITH IR LINE SCANNING DEVICE FOR OBSERVATION AND CORRELATION IN TWO SPECTRA; MULTISPECTRAL CAMERA, IR DEVICE AND SIDE-LOOKING RADAR WITH EMPHASIS ON RADAR EXPERIMENTS AND CORRELATION OF SENSOR OUTPUTS; MULTISPECTRAL SENSORS TO PERMIT SYNOPTIC COVERAGE OF METEOROLOGICAL PHENOMENA.

BIOMEDICAL & BEHAVIORAL

OBJECTIVE: EFFECT OF WEIGHTLESSNESS AND CONFINEMENT. DETERMINE MAN'S PERFORMANCE. IMPROVE OPERATING EFFECTIVENESS

MISSION CHARACTERISTICS: ZERO-G. EXTENDED EXPOSURE. CONDUCT EXPERIMENTS AND RESEARCH PROGRAM

EXPERIMENTS: INCREASING TIME OF ZERO-G EXPOSURE. EQUIPMENT OPERATION. SPACECRAFT MANEUVERING. EXTRA-VEHICULAR ACTIVITIES

TEN BASIC BODY SYSTEM MEASUREMENTS:

CARDIOVASCULAR	FLUID AND ELECTROLYTE BALANCE
HEMATOLOGICAL	NEUROLOGICAL
RESPIRATORY	DIGESTIVE
MUSCULOSKELETAL	ADAPTATIVE
METABOLIC	PSYCHOMOTOR FUNCTIONS

LIMITING FACTORS: EXPERIMENTAL EQUIPMENT DEVELOPMENT

PROSPECTS FOR SOLUTION: EQUIPMENTS ARE WITHIN STATE OF THE ART. EXTENSION OF MERCURY/GEMINI/APOLLO TECHNIQUES. DEVELOPMENT FUNDING REQUIRED

FLIGHT PROGRAM: EXPERIMENTS WILL MEASURE CARDIOVASCULAR, RESPIRATORY, HEMATOLOGICAL, MUSCULOSKELETAL, METABOLIC, FLUID AND ELECTROLYTE BALANCE, NEUROLOGICAL, DIGESTIVE, ADAPTION AND PSYCHOMOTOR FUNCTION. HEAVY SCHEDULING OF BIOMEDICAL EXPERIMENTS OF FIRST FLIGHTS OF A GIVEN DURATION. SAME EXPERIMENTAL PACKAGE OF SECOND FLIGHT OF GIVEN DURATION TO PROVIDE VALIDATION POINTS AND INSURE ABILITY TO MAKE DETAILED EVALUATION. HEMATOLOGICAL AND CARDIOVASCULAR EVALUATIONS PLANNED FOR ALL EARTH-ORBITAL MISSIONS.

LUNAR ORBITAL SURVEY

OBJECTIVES: TOPOGRAPHIC AND SITE SELECTION DATA. MAPS AND SURVEYS OF ENTIRE SURFACE

MISSION CHARACTERISTICS:

ORBIT	*DURATION*
LOW EQUATORIAL	TO 28 DAYS
POLAR	TO 28 DAYS

EXPERIMENTS: PHOTOGRAPHY; PROBES; RADAR; IR AND GAMMA-RAY SURVEY; UV SPECTROMETRY; MICROWAVE; X-RAY SPECTROSCOPY; VHF REFLECTIVITY

LIMITING FACTORS: PROBE DEVELOPMENT. DATA HANDLING EQUIPMENT. EXTENDED DURATION SUBSYSTEMS

PROSPECTS FOR SOLUTION: EQUIPMENT MODIFICATION REQUIRED. FUNDING FOR MODS OR DEVELOPMENT REQUIRED

FLIGHT PROGRAM: NOT AVAILABLE.

COMMUNICATIONS

OBJECTIVE: EXPLOIT ADVANTAGES OF SPACE FOR DIRECT HOME RADIO AND TV COMMUNICATIONS, AND FOR GROUND POINT TO POINT AND DEEP SPACE TO GROUND COMMUNICATION RELAY

MISSION CHARACTERISTICS: SYNCHRONOUS ORBITS FOR CONTINUOUS COMMUNICATION EXPERIMENTS. LOW ALTITUDE ORBITS FOR OTHER COMMUNICATIONS RESEARCH

EXPERIMENTS: UHF TRANSMISSIONS UTILIZING A 30-FOOT INFLATABLE ANTENNA. FM RADIO TRANSMISSIONS COVERING LARGE AREAS OF THE EARTH CONTINUOUSLY.

NOISE SPECTRAL TEMPERATURE MEASUREMENTS. DETAILED STRUCTURE PATTERNS OF LARGE EARTH-BASED ANTENNAS

LIMITING FACTORS: EFFICIENT PRIME POWER SOURCE FOR LONG DURATION NOT AVAILABLE. EQUIPMENT REPACKAG-

ING AND INFLATABLE ANTENNA DEVELOPMENT REQUIRED

PROSPECTS FOR SOLUTION: FUEL CELLS MAY BE USED FOR POWER UNTIL RADIOISOTOPE UNITS CAN BE DEVELOPED. RE-PACKAGING CAN BE ACCOMPLISHED WITHIN PROPOSED SCHEDULE BY IMMEDIATE IMPLEMENTATION. DEVELOPMENT FUNDING REQUIRED

FLIGHT PROGRAM: TWO FLIGHTS. ONE WILL EMPHASIZE UHF TV BROADCASTING TRANSMITTED TO HOME RECEIVERS OVER A 1,000-MI.-RADIUS AREA. SECOND WILL BROADCAST OVER RADIO FREQUENCIES COVERING LARGE AREAS OF EARTH CONTINUOUSLY. EXPERIMENTS TO PROVIDE BASE FOR RELAYING COMMUNICATIONS GROUND TO GROUND AND DEEP SPACE TO EARTH. ALSO MEASUREMENT OF STRUCTURE PATTERNS OF EARTH-BASED ANTENNAS.

MAPPING AND SURVEY

OBJECTIVE: EXPLORE FEASIBILITY OF MANNED SPACE FLIGHT TO DEVELOP SYNOPTIC, MULTISENSOR MAPPING OF EARTH FOR PEACEFUL PURPOSES.

MISSION CHARACTERISTICS: INITIAL FEASIBILITY IN LOW INCLINATION AND ALTITUDE ORBIT. LONG DURATION POLAR FLIGHTS FOR GLOBAL COVERAGE. LONG DURATION SYNCHRONOUS ORBITS FOR CONTINUOUS COVERAGE

EXPERIMENTS: SYNOPTIC GLOBAL COVERAGE AND CORRELATION OF SIGNIFICANT OUTPUTS FOR EACH AREA OF RESEARCH USING MULTISPECTRAL CAMERA, IR LINE SCANNING IMAGERY, THREE-FREQUENCY SIDE-LOOKING RADAR, MICRO-WAVE RADIOMETER.

LIMITING FACTORS: THREE-FREQUENCY SIDE-LOOKING RADAR FEASIBLE BUT NOT DEVELOPED. DATA HANDLING EQUIPMENT. LONG DURATION SUBSYSTEMS

PROSPECTS FOR SOLUTION: RADAR CAN BE DEVELOPED WITHIN 36 MONTHS. PRESENT SUBSYSTEM EXTENSIONS FEASIBLE. FUNDING REQUIRED FOR EQUIPMENT DEVELOPMENT

FLIGHT PROGRAM: THREE-FLIGHT PROGRAM EVOLVES FROM USE OF INDIVIDUAL SENSORS AND CORRELATION OF SIGNIFICANT OUTPUTS. PURSUED IN CONJUNCTION WITH METEOROLOGICAL PROGRAM. ONE FLIGHT DEVOTED TO SYNOPTIC, MULTISENSOR COVERAGE OF EARTH. DEVICES USED ARE MULTIBAND CAMERA, IR LINE SCANNING IMAGERY AND SIDE-LOOKING RADAR. EMPHASIS ON EXPERIMENTS WITH MICROWAVE RADIOMETER AND CORRELATION OF SIGNIFICANT OUTPUTS OF OTHER SENSORS FOR SYNOPTIC COVERAGE.

OPERATIONS CAPABILITY

OBJECTIVE: DEVELOP CAPABILITY FOR MANNED OPERATIONS IN SPACE SUCH AS:

1. FEASIBILITY OF FLIGHT INTO ALL USEFUL ORBITS
2. PLANE AND ORBIT ALTITUDE CHANGES
3. LOGISTICS FEASIBILITY
4. NON-COOPERATIVE RENDEZVOUS
5. EXAMINATION OF PREVIOUS SATELLITES

MISSION CHARACTERISTICS: POLAR AND SYNCHRONOUS ORBITS. CSM AND LEM FLIGHTS. MULTIPLE MISSIONS. RENDEZVOUS, DOCKING, ASSEMBLY AND TRANSFER

LIMITING FACTORS: SPACECRAFT AVAILABILITY. COMMAND AND CONTROL

PROSPECTS FOR SOLUTION: ADDITIONAL GROUND EQUIPMENT REQUIRED. SLIGHT MODIFICATION TO FLIGHT SUBSYSTEMS. DEVELOPMENT FUNDING REQUIRED

FLIGHT PROGRAM: FIVE FLIGHTS SCHEDULED. ONE EXPERIMENT WILL EMPHASIZE MAN'S PARTICIPATION IN PLANE CHANGING AND MANEUVERING TO SIMULATE SIMPLE RENDEZVOUS AND MANEUVERING OF ASTRONAUT OUTSIDE THE VEHICLE. ONE AIMED AT EXTERNAL METHODS OF MAINTENANCE AND REPAIR. ANOTHER WILL FOLLOW-ON WITH EXTRAVEHICULAR MOBILITY METHODS, FASTENING AND ASSEMBLY TASKS. TWO FLIGHTS WILL RENDEZVOUS AND DEMONSTRATE CARGO TRANSFERAL, INCLUDING FLUID HANDLING. ACTIVITY FOR RESCUE RETRIEVAL AND REPAIR WILL BE CONDUCTED.

ASTRONOMY

OBJECTIVE: ASTRONOMICAL OBSERVATION OF PLANETS, SUN, STARS AND NEBULAE WITHOUT ATMOSPHERIC ABSORPTION OR DISTORTION

MISSION CHARACTERISTICS: EXTENDED MISSION DURATION IN LOW INCLINATION EARTH ORBIT

EXPERIMENTS: PROGRAM EVOLUTION FROM INITIAL CHECKOUT TASKS TO SOPHISTICATED CORRELATED OBSERVATIONS USING:

40-INCH WIDE-BAND OPTICAL TELESCOPE WITH SPECTROPHOTOMETRIC AND IMAGING MODE

SMALL-DIAMETER SOLAR CORONOGRAPH FOR SOLAR CORONA AND FLARE STUDIES

20-FT.-DIAMETER RADIO TELESCOPE ERECTED IN SPACE

LIMITING FACTORS: SPECIFIC HARDWARE STUDIED BUT NOT YET DEVELOPED

PROSPECTS FOR SOLUTION: PRESENT EQUIPMENT CAN BE USED, DESIRED INSTRUMENTS CAN BE DEVELOPED IN 3 YEARS. NO BREAKTHROUGH REQUIRED. DEVELOPMENT FUNDING REQUIRED

FLIGHT PROGRAM: TWO FLIGHTS IN EARTH ORBIT WITH TOTAL STAY-TIME UP TO 150 DAYS. SECOND FLIGHT TO RENDEZVOUS 60 DAYS AFTER FIRST FLIGHT TO EXTEND MISSION TIME. RADIO TELESCOPE 30 FT. IN DIAMETER TO BE ERECTED AND CHECKED OUT IN ORBIT.

RESEARCH & TECHNOLOGY

OBJECTIVE: EXTEND SCIENTIFIC KNOWLEDGE. DEVELOP TECHNOLOGY FOR FUTURE SPACE ACTIVITIES

MISSION CHARACTERISTICS: ZERO-G AND SPACE ENVIRONMENT. LOW INCLINATION AND ALTITUDE ORBITS

EXPERIMENTS: BIOSCIENCE, PHYSICS, CHEMISTRY AND MATERIALS RESEARCH. EXAMPLES: TISSUE REGENERATION/HEALING, BACTERIOLOGY, GERMINATION, GAS ABSORPTION BY LIQUIDS, COMBUSTION OF MATERIALS, SURFACE TENSION, SURFACE CHEMISTRY, HEAT TRANSFER, FRACTURE MECHANICS SPACE EXPOSURE EVALUATION FOR A WIDE VARIETY OF MATERIALS, METEOROID EXPERIMENTS, MECHANICAL SUBSYSTEMS, PASSIVE ERECTION OF LENTICULAR MODELS, DEVELOPMENT OF STABILIZATION AND CONTROL SYSTEM AND RADIOISOTOPE POWER SYSTEMS, AND QUALIFICATION OF THE ABOVE SYSTEMS

LIMITING FACTORS: FLIGHT HARDWARE MUST BE DEVELOPED

PROSPECTS FOR SOLUTION: TECHNICAL FEASIBILITY ESTABLISHED FOR MOST EXPERIMENTS. FURTHER STUDY AND DEVELOPMENT REQUIRED. DEVELOPMENT FUNDING REQUIRED.

FLIGHT PROGRAM: DEVELOPMENT WILL BE ACCOMPLISHED OVER THE ENTIRE FLIGHT PROGRAM WITH PARTICULAR EMPHASIS ON FIVE FLIGHTS. EXPERIMENTS WILL BE CONCERNED WITH SPACE EXPOSURE EVALUATION FOR A VARIETY OF MATERIALS, METEOROID EXPERIMENTS, MECHANICAL SUBSYSTEMS AND PASSIVE ERECTION OF LENTICULAR MODELS, DEVELOPMENT OF ENVIRONMENTAL CONTROL SYSTEM, STABILIZATION AND CONTROL SYSTEM AND RADIOISOTOPE POWER SYSTEMS; CHECKOUT OF GRAVITY-GRADIENT STABILIZATION AND DEVELOPMENT OF A MULTIPLE-BEAM PHASED-ARRAY ANTENNA.

HONEYWELL INSTRUMENTATION

Two New Instruments Expand Line of Strip Chart Recorders

PHILADELPHIA — Introduction of the *ElectroniK 16* wide-chart recording potentiometer and the *ElectroniK 19* portable laboratory recorder greatly increases the performance capability of Honeywell strip chart recorders for test facility and laboratory use.

The *ElectroniK 16* recorder is extremely convenient to install, maintain and use. It mounts directly into a 19-inch relay rack without adapters or filler panels and has a new, high-performance, transistor servo-measuring unit. Chart-changing has been greatly simplified and an optional chart transport, which can be preloaded, permits charts to be changed in approximately 10 seconds. The *ElectroniK 16* is available in single, two-pen or multipoint models.

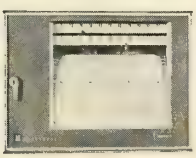
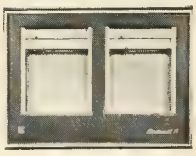
Mechanical layout of the recorder is such that most available options and accessories have their own unique locations on the chassis. Many options can be added later in the field—no need to return the instrument to the factory.

The *ElectroniK 19* portable lab recorder, a highly versatile instrument, is capable of measuring voltages from 100 microvolts full scale to 100 volts dc full scale without auxiliary equipment. Among other features, it has a tilting chart platen and thumb-wheel selection of 10 chart speeds.

The well-known *ElectroniK 17* recorder is ideal where mounting space must be conserved and accurate, low frequency dynamic measurements are required. The instrument features the infinite resolution *Stranducer* rebalancing element and solid-state circuitry. One or two independent full-width recording channels can be provided on a six-inch strip chart. Two chassis, each with one or two recording channels, allow recording of up to four independent channels in only 14 inches of vertical space in a standard 19-inch relay rack.

The *ElectroniK 18*, a single-pen, small-case recorder, is suitable for many demanding assignments, where equipment cost must be minimized.

ABRIDGED SPECIFICATIONS FOR STRIP CHART RECORDERS

				
	ElectroniK 16 (Single, Two-Pen and Multipoint Recorder)	ElectroniK 17 (2, 3, or 4-Pen Recorder)	ElectroniK 18 (Single-Pen only)	ElectroniK 19 (Single and Two-Pen)
Calibrated Accuracy	±¼ of 1% of span for mv ranges	±¼ of 1% of span	±3/10 of 1% of span	±¼ of 1% of span or 1 microvolt, whichever is greater
Dead Band	0.1% of span	0.15% of span	0.2% of span	0.15% of span
Chart Speeds	From ½ inch/hr. to 4 inches/second	½ to 480 inches/hr. single speed; up to 3600 inches/hr. with jump speed	½ to 120 inches/hr.	10 indicated speeds from 10 minutes/inch to 1 second/inch plus "stand-by"
Chart	11-in. calibrated width, 122 ft. long	6-in. calibrated width. 126 ft. long	6-in. calibrated width, 126 ft. long	6-in. calibrated width. 126 ft. long
Span Step Response Time	1 second full scale	1 second full scale	1 second full scale	Less than 0.5 second full scale
Calibration	D-C voltages and currents, thermocouple, radiation pyrometer, resistance thermometer, tachometer	D-C voltages and currents, thermocouple, radiation pyrometer, resistance thermometer, tachometer	Thermocouple, radiation pyrometer, millivolts, milliamperes	D-C voltages
Ranges	Minimum 1 millivolt full scale Maximum 300 volts full scale	Minimum 1 millivolt full scale Maximum 300 volts full scale	Minimum 1 millivolt full scale Maximum 100 millivolts full scale	0.1, 0.2, 0.5, 1.0, 2.0, 5.0, 10, 20, 50, 100 millivolts full scale and 0.2, 0.5, 1.0, 2.0, 5.0, 10, 20, 50, 100 volts full scale
Approximate Weight	85 lb.	Single chassis 46 lb. Dual chassis 116 lb.	46 lb.	Less than 20 lb.
Price Range (no options included)	$1000—1975	$755—2680	$615	$1100 net
Circle reader service card #	25	26	27	28

(All prices and specifications subject to change without notice.)

HONEYWELL, Philadelphia Div., Philadelphia, Pa. 19144 • Denver Div., Denver, Col. 80217

NEWS

MILITARY EDITION

Number 3-MI

Four *Visicorder* Oscillographs Offer Flexibility in Dynamic Data Recording

DENVER—Honeywell's line of direct-recording *Visicorder* oscillographs now includes models to fit almost every conceivable data recording need in the aerospace and scientific areas.

The 36-channel Model 1612 instrument, for instance, is available in a configuration that meets rigid military specifications for radio frequency (RFI) suppression. Another optional feature of the Model 1612 permits use of the new Eastman *Ektaline* and Du Pont fast-processing develop-out papers, as well as conventional photographic recording papers.

The Model 1508, like the Model 1612, is designed for rack-mounting in data systems. It records up to 24 channels of data simultaneously, yet occupies only seven inches of rack height.

The Model 1108, the most complete 24-channel oscillograph on the market, and the small, inexpensive Model 906, a 14-channel instrument, are designed primarily for bench use.

All four instruments are based on the Honeywell-developed principle of using ultraviolet light to record data on light-sensitive paper, thus providing instantly readable, permanent oscillographic records without chemical processing.

The accompanying chart shows the outstanding features of each instrument.

8 Graphic Recorders Fill Test Data Needs

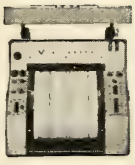
PHILADELPHIA—Eight graphic recorders now available from Honeywell's Philadelphia and Denver Divisions will satisfy most requirements for the recording of missile data falling in the DC-6000 cps range. The group includes four *Visicorder* oscillographs and four strip chart potentiometric recorders.

The wide choice of instruments available, along with the variety of options offered, enables users to select recording systems or individual units that will efficiently meet requirements. The instruments can be specified for rack or panel mounting, with laboratory feet, or for mounting in mobile consoles.

ABRIDGED SPECIFICATIONS FOR *VISICORDER* OSCILLOGRAPHS

HONEYWELL









	1612	1108	1508	906
No. of Channels	36	24	24	14
Paper Width	12″	8″	8″	6″
Paper Speeds	15—.1 to 160 ips	15—.05 to 80 ips	12—.1 to 80 ips	4—.4 to 50 ips
Frequency Response	DC-6000 cps	DC-6000 cps	DC-6000 cps	DC-6000 cps
Writing Speed	50,000 ips +	50,000 ips +	50,000 ips +	50,000 ips +
Record Reverse	Yes	Yes	No	No
Heated Platen	Optional	No	Optional	No
Latensifier	Optional	Optional	Optional	Optional
Paper Takeup	Built-in	Built-in	Optional	Optional
RFI Qualified	Yes—Optional	No	No	No
Develop-Out Capability	Yes	Yes	Yes	No
Gridlines	Built-in	Built-in	Built-in	Optional
Time Lines	Optional	Built-in	Optional	Optional
Trace Identification	Built-in	Built-in	Built-in—Optional	Optional
Trace Numbering	Optional	No	Optional	No
Galvo Intensity Control	Auto & Manual—Built-in	Manual—Built-in	Manual—Built-in	Optional
Remote Operation	Yes	Yes	Yes	Yes
Auto. Record Length Control	Built-in	Built-in	No	No
Paper Supply Indicator	Built-in	Built-in	Built-in	Built-in
Price Range	$7850-14,375	$4925-5275	$2775-5875	$1855-2700
Circle reader service card #	29	30	31	32

(All prices and specifications subject to change without notice.)

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Honeywell

Douglas Due to Get New MORL Award

THE DOUGLAS AIRCRAFT CO. will receive a new NASA contract in about two weeks to continue its study of the *Manned Orbiting Research Laboratory (MORL)*, which would cost close to $2.5 billion to achieve a one-year operational capability.

A five-year operational program would have a price tag of just over $4 billion.

The space station itself would cost about $800 million in the one-year program. Other costs, based on NASA studies, would be 33% for the logistic systems, 14% for program management, 11% for the flight crew, 4% for mission operations and 3% for facilities.

For a five-year system, the cost of the logistic carrier and mission operations increases sharply while others drop off, including the lab, which slips to only 21% of the total.

● **Design concept**—MORL, under the Douglas concept, would support six men for 90 days or nine men for 60 days. Missions from two to 10 years would be carried out by using an *Apollo* spacecraft logistics carrier for periodic 90-day re-supply.

The lab would be 42 ft. long and almost 22 ft. in diameter; total volume would be 4,500 cu. ft. It would have five separate compartments. The hangar/test area would have a volume of 2,117 cu. ft. and be 192 in. long. The dimensions of the others include: operational/experiment area, 2,396 cu. ft. and 80 in.; centifuge, 1,198 cu. ft. and 40 in.; crew quarters, 2,088 cu. ft. and 111 in.; interstage, 81 in. long.

Other program details which have been studied, but remain to be definitized, are an altitude of 200 mi. for Earth-orbit missions, a centrifuge with a one- or two-man capacity and a capability of going to 9 g's, an environmental control system of 7 psi and a two-gas oxygen/nitrogen system.

The station propulsion system will probably be storable hypergolic radiation-cooled engines with a 50-lb.-thrust reaction-control system and a 150-lb.-thrust system for orbit station keeping. The power supply will be provided by solar cells and batteries.

● **Changes in thinking**—While Headquarters manned space flight officials are satisfied with *MORL's* outside configuration, they feel that some changes in its internal compartmentalization may be necessary.

The change grew out of a switch in the initial concept, which originated two years ago when interest in the station stemmed primarily from its potential as a testbed for studying the effects of long periods of weightlessness on man. Now NASA wants to assess the effect of application-oriented experiments on the internal design.

In addition to this, Douglas, under its new award, will also study the effects of adding radar and camera equipment as well as the requirements of the polar, synchronous and deeply elliptical orbit and the logistic considerations for such orbits.

Two means of access are provided in the *MORL* configuration—one through the hangar/test area and one through the aft airlock. The *MORL* facility is managed from the control, operations and experimental deck. The major portion of the experimental program is conducted and controlled from this area. The quarters deck for the flight crew is specifically for off-duty requirements. Between the quarters and operations decks is the centrifuge.

● **Interior configuration**—The hangar/test area is separated from the forward pressure compartment by an inverse-pressure bulkhead. The area will act as a transfer airlock for personnel moving from the logistics spacecraft into the laboratory. The area also provides interim storage for cargo before final storage or external deployment, and emergency quarters for the crew in case of problems in the main pressure shell. The area is so designed that the crew could live there and control the laboratory for extended periods while repairing the lab compartment.

The control deck is divided into four areas by consoles and partitions. One console is associated with operations, command and control of the station, one with experimental control, two with experimental procedures. Some of the liquid and liquid-related studies will be conducted in a separate filtered compartment to avoid contamination of the laboratory.

The flight crew quarters provides six personnel compartments for sleeping and personal storage. A crew of more than six will share compartments, using a bedroll arrangement.

● **Facilities**—Maximum use will be made of existing facilities, but there are some requirements for new construction and development.

At NASA's Merritt Island launch complex, the *Apollo* spacecraft operations and checkout building now under development, the environmental test complex and the attitude-control chamber can be used if MORL or a similar station is approved.

New facilities there would include the development of Pad 37A for the back-up *Apollo* spacecraft logistics carrier. This will also mean that complex will have to have independent checkout structures for each of its two pads. Another new building project would be an operations and checkout building for *MORL* and the cargo module of its logistics carrier.

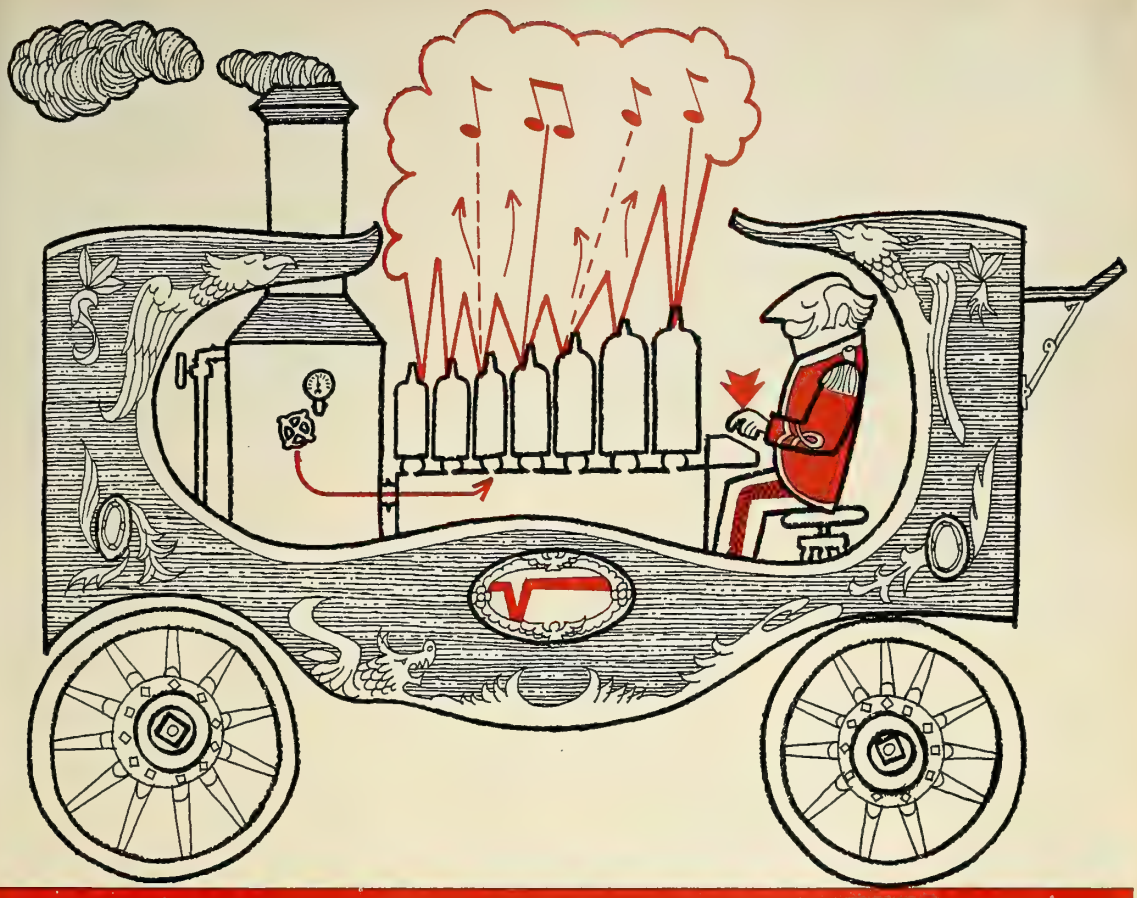
At the Manned Spacecraft Center, the current Missions Control Center as well as the checkout and simulation facilities could be used. New training facilities for the flight crew will be needed. Other new buildings required include an operations and control center to handle the routine functions of the space station as well as a facility for the experimental program.

● **Alternate missions**—In addition to its routine Earth-orbit missions, some of the alternate missions considered include high-inclination, synchronous and lunar orbit. The *Saturn IB* would be used for Earth-orbit flights and the three-stage *Saturn V* would be used for high-inclination lunar orbit and synchronous missions.

For the high-inclination polar mission, no subsystems will be changed, but the amount of radiation protection will have to be increased in ratio to the degree of inclination with a probable maximum of 13,500 lbs. at 90°.

For the synchronous mission, operations in the Van Allen radiation belt will force the use of additional amounts of shielding, and a biowell will be needed for protection against possible solar flares. Because of the long distance from Earth, the communications system will have to be switched to the *Apollo* unified S-band system. The payload for experiments for such a flight may be as great as 5,400 lbs.

The lunar orbit mission also means that a biowell weighing perhaps 4,000 lbs. will be needed. The environmental control system will require the addition of a small amount of thermal storage because of the change in light-to-dark ratios. Again, the unified S-band will be needed. Experimental payload will be about 3,500 lbs. ■



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Equipment for Intensive Moon Studies Will Be Developed Within 15 Months

Plans also include program definition of modified LEM during FY '66, further investigation of LEM truck and Mobile Laboratory

SPACE AGENCY officials expect to be ready within 12 to 15 months to begin hardware development of a logistics system for extended exploration of the Moon.

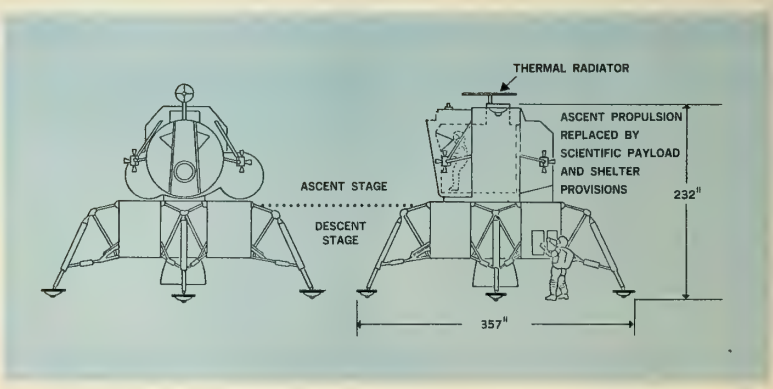
It will be based in part on a report of a group of eminent geologists and geophysicists who had been asked by NASA to recommend a plan on how the Moon should be explored. The report is due at NASA's Office of Manned Space Flight in about three months.

At the same time, the agency is moving ahead with plans to go into the program-definition phase in FY '66 of a modified Lunar Excursion Module, which would provide up to 14 days of stay-time on the Moon.

The space agency will also continue studies of such logistics systems as the LEM truck spacecraft and its MOLAB (Mobile Laboratory) payload and other logistics systems.

E. Z. Gray, director of Advanced Mission Studies in the Office of Manned Space Flight, told MISSILES AND ROCKETS that at the end of the 15-month period the agency will go to hardware development and funding for a system designed to extend lunar exploration capability. He also said there may be some funding of long leadtime systems, such as power, in FY '66.

The LEM truck spacecraft and its MOLAB payload will not receive any appreciable NASA funding until Fiscal 1967 at the earliest. In addition, MOLAB is now getting some competition from the Manned Spacecraft Center's proposal for a mobility capability involving putting wheels on the LEM's ascent propulsion stage and using it to get surface mobility. At the same time, Grumman Aircraft Engineering Corp. has proposed putting wheels on the LEM itself to gain mobility after the lunar touchdown. A lunar jeep that would take astronauts on exploring missions is also being studied.



NASA ARTIST'S DRAWING of modified Lunar Excursion Module.

● **$3-billion pricetag for 90 days**—The eventual objective of these projects—setting up a base with a minimum 90-day capability—would cost $3 billion, according to conservative estimates by NASA officials. At this point, the agency is not sure it wants to set up a base and will not know definitely until after the first lunar landing. As a result, there is a definite slowdown in the rush to develop cargo carriers for operations on the Moon.

Total cost of redesigning the LEM into a supply vehicle for lunar missions is expected to be less than $100 million. This does not include other cost factors in the program, such as basic cost of a LEM, management support, facilities and launch vehicles.

The first step—which will be taken in the next Fiscal Year—will be removal of the propulsion system from the ascent stage of the LEM. This will provide 1,300 cu. ft. of additional space and about 6,000 lbs. in weight saving. The move will be taken as part of the program definition of *Apollo* extension systems.

About half, or 3,000 lbs., will be used to provide a shelter for two astronauts; the other half will be used to provide power and life support equipment for the additional stay-time. Consideration is also being given to sending along a small 300 to 400-lb. unmanned roving vehicle similar to the one which will be flown during the *Surveyor* spacecraft flights to the Moon. It would have a range of about 25 km.

It is doubtful at this point that there will be any real hardware funding in the next Fiscal Year, but the project will almost certainly go ahead in FY '67.

● **Auto pilot needed?**—The probable next step in the lunar exploration program—the LEM truck spacecraft—has run into a technical problem that still has not been outlined or solved. During manned LEM flights, the astronauts will control the final phases of the



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Preliminary LEM Truck Design Data

Item	Truck Weight	Remarks
STRUCTURE	(1,152.6)	The RCS thrusters must be relocated within the shroud and below the adapter pick-up fittings to insure no interference with payload removal. The interstage attachment may require modification to accommodate the installation of the turntable at LEM Station 198. Electronic equipment and fuel tanks can be arranged in the four diagonal compartments for balance of the vehicle. Adequate doors can be provided for servicing and installation. Small structural changes will be required for mounting antennas and the RCS engines.
Descent Stage Structure		
Skin	142.8	
Beams and Bulkheads	300.1	
MM Shielding	—	
Thermal Protection	214.3	
Supports (Incl. Egress Platform)	195.2	
L. G. Support Truss	81.2	
Separation System	29.0	
S IV B Attachment Penalty	24.0	
Ladder	26.0	
Equipment Supports and Access Penalties	50.0	
STABILIZATION AND CONTROL	(108.1)	Programming for abort is not required for LEM truck operation. All other components identical to LEM but integrated into descent stage. Command control section included for unmanned remote control.
NAVIGATION AND GUIDANCE	(276.8)	The LEM navigation and guidance system can be used for the LEM truck. All components with the exception of the automatic optical telescope (AOT) will be required. The AOT can be replaced by an automated star acquisition and tracking system to align the IMU platform This system is completely automatic to touchdown; the basic automatic program can be stored in the LEM guidance computer (LGC). Required star tracking system accuracy is approximately one-half milliradian. Manual control is possible during the final descent and hover on the LEM mission to permit final landing site selection. Similar site selection capability can be provided on the LEM truck through a television system relaying video to the CSM on the VHF communication link. Commanding of the LEM truck computer can be provided from a parallel display keyboard (DSKY) in the CSM, similar to the keyboard planned for LEM.
GFE		
Inertial Measurement Unit	42.0	
Automatic Optical Telescope (Star Tracker)	24.5	
LEM Guidance Computer	46.3	
Power Servo Ass'y	50.1	
Cabling	10.0	
Rendezvous Radar	75.9	
Landing Radar	28.0	
Obstacle avoidance TV	—	
ENVIRONMENTAL CONTROL	(128.0)	Only thermal control required. Thermal control system basically the same as LEM except for relocation of subsystems in descent stage. During the translunar standby period, the electrical power requirements can be minimized by special treatment of the IMU. The IMU would be thermally insulated and heated during translunar standby. For the check-out and operating periods, a separate closed-loop cold plate/water boiler would be provided.
Heat Transport Section (Coolant Pump)	50.0	
Water Management Section	58.0	
Plumbing	20.0	
LANDING GEAR	(402.0)	No change from LEM.
INSTRUMENTATION	(156.5)	One half the number of signal conditioners and sensors are required for the LEM truck configuration due to the removal of the ascent structure and engine, life-support ECS, and scientific equipment. There is also no requirement for on-board displays, storage recorder, and emergency detection and warning assemblies. On-board checkout can be programmed for automatic operation. Status data can be transmitted to the CSM for display and/or transmission to Earth via the CSM S-band communications system. During CSM/GOSS blackout. the status data could be recorded on board the CSM for delayed transmission to Earth.
Operational		
Signal Conditioner	23.0	
PCMTE	31.5	
Inflight Status System		
On-Board checkout equipment	25.0	
Sensors	76.0	
ELECTRICAL POWER SUPPLY	(643.6)	Power is required for LEM truck mission for checkout (1.0 hour), descent (1.5 hour), and standby (72 hours). Standby power is required to provide thermal control of the IMU, and for VHF command receiver operation. Total power required is estimated to be 6,113 watt hours. Batteries have been selected due to the short duration and low power requirement. Estimated weight includes a 50% redundancy.
Power Conversion Section (Inverter)	25.0	
Distribution Section	80.0	
Electrical Provisions	338.6	
Batteries	200.0	
PROPULSION SYSTEM	(16,364.5)	Descent propulsion weight is reduced by the amount of fuel saved in landing less inert weight (500 lb—2 crewmen).
REACTION CONTROL SYSTEM	(551.4)	The LEM components can be used on the LEM truck.
Communications	(46.1)	Communications will be required during the translunar checkout (approximately one-half hour) and from lunar orbit checkout to final touchdown (approximately two hours). The VHF communications link between the CSM and LEM truck will provide the necessary information channel. Status data and video information can be transmitted on the up-link to the CSM and commands received on the down-link. This is a major modification in LEM communications and would require new equipment in both the LEM truck and the CSM.
VHF LEM/CM	35.6	
Television	10.5	

LEM touchdown. Since the LEM truck will be an unmanned vehicle, a question has been raised as to whether it should be equipped with an automatic obstacle avoidance system designed to control the last 20 or 30 ft. to prevent a crackup.

Such a system would be very complex and expensive. The Massachusetts Institute of Technology was recently awarded a contract to study the whole problem, to determine if such a system is needed and, if so, what technical approach should be used. Dr. Wilbur Defrees, director of Marshall Space Flight Center's Extended Lunar Exploration Studies, does not believe it will be worth the trouble to build it, but if a decision is made to proceed with it, the system could delay development of the LEM truck.

The LEM truck requires removal of the whole ascent vehicle from the module. The guidance and control and power systems would have to be repackaged into the LEM truck. The attitude-control nozzle would also have to be moved from the ascent stage to the landing stage.

The truck would be used for lunar exploration missions ranging from 3-5 days up to two weeks. The landing site would be within 10 degrees of the Moon's equator. Its primary scientific missions would be surface and subsurface geology, drilling, seismic survey, photography, astronomy, environmental data and surface mobility.

It is difficult to assess the prospects of success for LEM's two new competitors, MOCAN and MOLEM. The agency is just getting ready to consider each of them in detail, and some funding of study contracts can be expected in the latter part of the current Fiscal Year and early next year. MOCAN involves a new laboratory module with wheels, which would replace the LEM ascent stage. MOLEM—with wheels on the LEM truck itself—is not given much support by the space agency at this point.

● **Partial to MOLAB**—NASA officials still lean strongly to the Mobile Laboratory concept as the best payload for the LEM truck. It is doubtful, however, whether it will receive any funding until late 1967 or 1968. Defrees estimates its development schedule will take 40 to 50 months. This means that it will not fly until 1972 at the earliest. While it is still too early to make a definite statement, NASA Headquarters estimates the total cost of its development at $300 million.

MOLAB would weigh some 6,000 lbs. plus. In addition, the LEM truck will carry 750 to 1,000 lbs. of scientific equipment to the Moon.

Two firms, Boeing Co. and Bendix Corp., have been awarded study contracts on MOLAB, which are to be completed next February. Each of them so far has decided that a horizontal cylinder is the best approach to the cabin configuration. The vehicle has six wheels and an articulated frame with each wheel. The wheels would be driven by an electric motor. The vehicle would provide a mobility range of 250 mi. and enough supplies for a two-week stay.

Some of the technical problems involved include cryogenic storage, a need for fuel cells with instant start, requirement for a closed system permitting reuse of water, and the dynamics of such a vehicle on the Moon.

● **No early decision**—NASA officials now believe there will be no decision on the establishment of a lunar base until late in this decade. Program definition might come as early as 1968, with system development beginning in 1969 or 1970. The prime logistic vehicle for such a system is the Marshall Space Flight Center's multi-purpose Mission Module. Launched by a *Saturn V* on a direct flight to the Moon, it would use three new propulsion stages, all powered by the RL-10 liquid hydrogen engine.

Its payload would include the three-ton MOLAB, another large shelter weighing three to four tons and another five tons of supplies. Its stay-time capability would be three to six months.

In developing the propulsion stages, the propellant tanks of the RL-10 would be cut or lengthened to provide a thrust from 15,000 to 40,000 lbs. for the stages.

In a NASA-funded study of the Lunar Exploration Systems for *Apollo*, the Boeing Co. recommended that the multi-purpose mission module could serve as a lunar logistic vehicle, advanced *Apollo* service module, and advanced LEM descent stage. The firm said that detailed studies of large-capacity *Apollo*- and LEM-type spacecraft, consistent with advanced *Saturn* performance in direct flight, Earth-orbit refueling and lunar-orbit rendezvous modes, should be pursued.

● **Surface emplacement preferred**—It said surface emplacement of a base is feasible and is preferable to subsurface emplacement. "Surface emplacement does not require unloading the basic shelter from the lunar logistic vehicle. Personnel shelters and other vulnerable elements should be designed to accommodate lunar soil coverage. The concept of an expandable caisson, built as part of the structure of the shelter to hold the soil cover, should be developed."

Other design details included:

—*Shelter*—Design of a basic, six-man lunar shelter with integrated meteoroid and radiation shielding adequate for one-year storage and subsequent three-month occupancy is feasible within the *Saturn V/LLV* payload limits. For longer operations, these shelters should be covered with lunar soil for added protection against the environment. A two-foot-thick layer of soil covering the shelter will provide the necessary shielding for up to two years of operations, assuming personnel are rotated at six-month intervals. Incorporating an expandable caisson in the shelter design to retain the soil cover is feasible.

—*Life support*—Life-support requirements can be met with the same techniques contemplated for advanced Earth-orbital systems, except for thermal control. New techniques will be required for thermal control. During the lunar day, reflective-radiation concepts may be used for heat rejection. Internally generated heat will be required to assist in temperature control during storage, possible from an easily shielded radioisotope heat source.

—*Power*—The study confirms that nuclear reactor power is the superior generation concept for all but the smallest bases. "The SNAP-8, 100-kilowatt, two-alternator system appears to be a very practical, reliable power module for application to large central nuclear powerplants on advanced bases." It recommended that further studies be made to verify a practical module size and that development effort be initiated on long leadtime items for such a system.

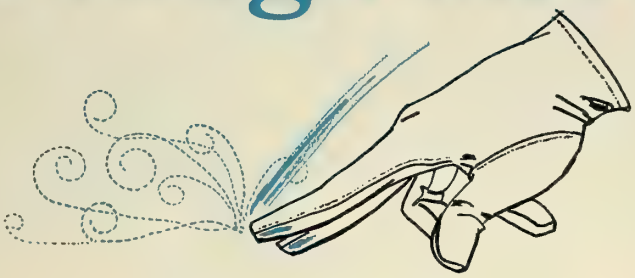
The small integral shelter power system could be developed for the 90-day base application. The Boeing engineers said the fuel cell/solar cell system appears to be the most practical concept, but that intensive studies should be made to evaluate and compare radioisotope concepts in the range from 1.5 to 3.0 kilowatts.

—*Communications*—"Lunar base communication requirements may be met with techniques that are well within the state of the art, except for point-to-point communications beyond the line of sight on the lunar surface. Existing and planned elements of the *Apollo* network can be used."

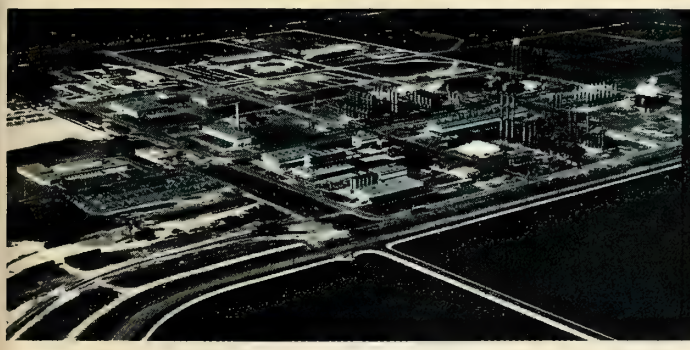
—*Fuel*—Cryogenics can be stored on the Moon for one year of unattended storage plus base operational periods. Regeneration of water into liquid hydrogen and liquid oxygen is both feasible and desirable for the larger bases.

—*Maintenance*—Maximum reliability plus a modest fault correction capability of the crew, rather than maximum maintainability, should become a major lunar-base design goal. The reduction of maintenance requirements should be pursued through design to eliminate all possible servicing needs during the projected base life, rather than through automated servicing needs or self-repair which may degrade rather than improve reliability. ■

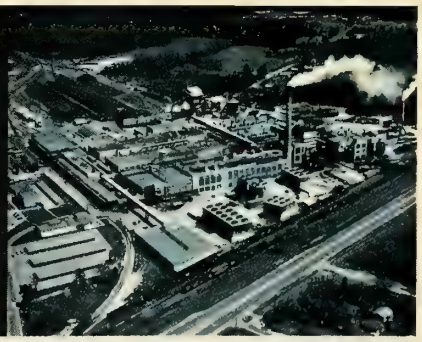
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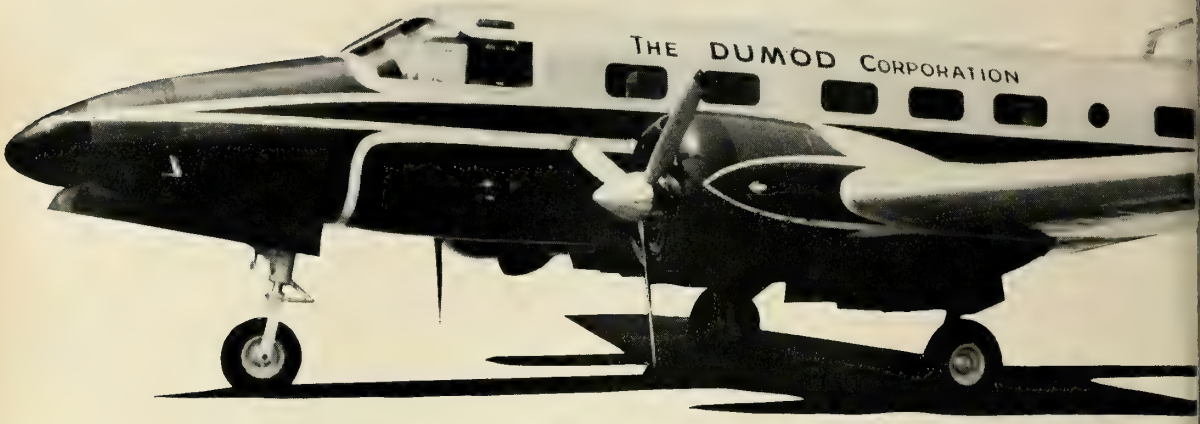
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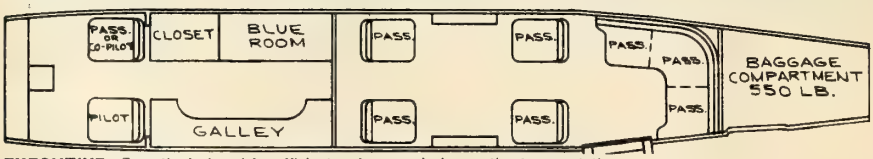
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Rate of climb (Sea level)— 1850 feet

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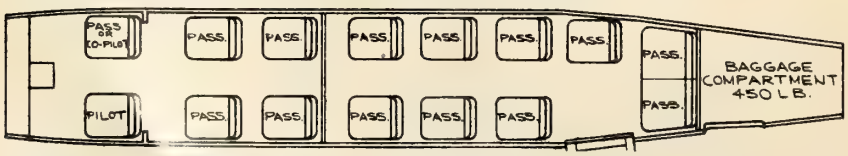
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Direct Operating Costs:	
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Oil (2 quart/hour per engine @ 50c)	2.00
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Reserve for engine and accessory overhaul	8.25
Radio and instrument overhaul	1.00
Total	$34.50
Indirect Operating Costs:	
Hangar rental ($1200 per year)	$ 1.71
Insurance (hull, all risk, groundflight, deductible)	5.14
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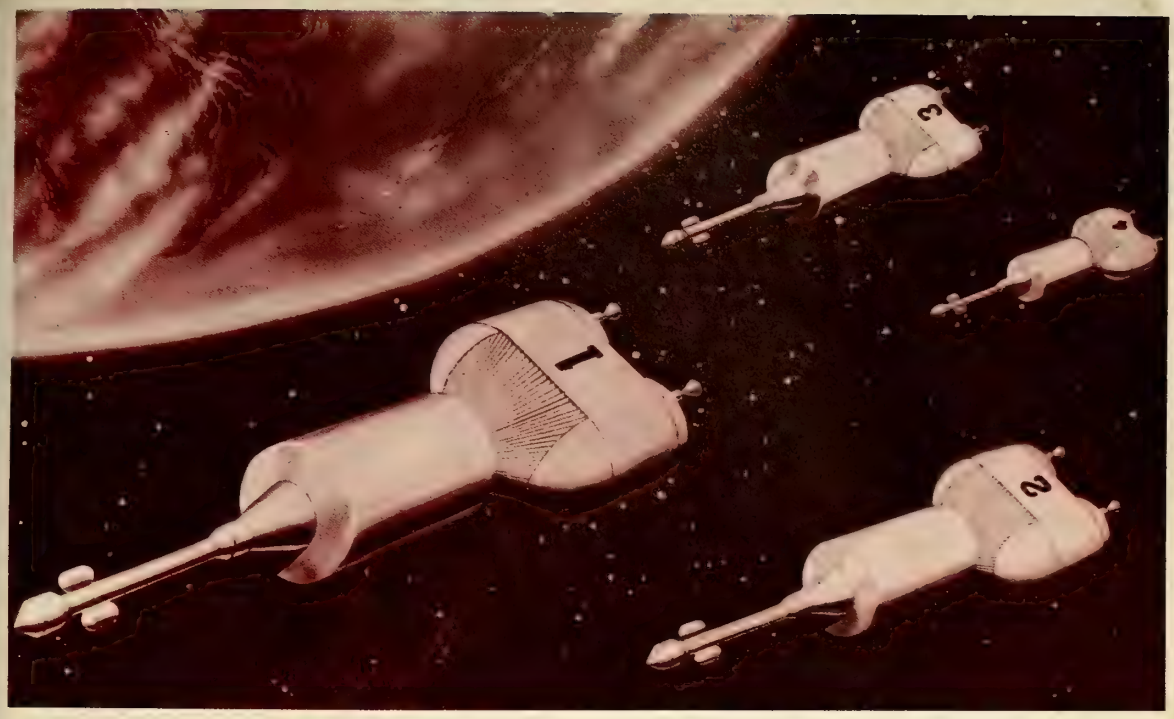
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NASA: Manned Mars Exploration

Need for More Accurate Information Sets Planned Landing Back to 1985

Wisely funded early studies now indicate no need to commit space agency to burdensome funding in immediate future

THE TARGET DATE for a manned Mars landing has now slipped to 1985.

As a result, NASA officials report that the only hard fact emerging from constant review of manned Mars missions is that there is no need for a major decision now or in the immediate future.

The space agency realized several years ago that minor funding into systems studies covering manned Mars missions would pay off handsomely the day the U.S. decided to place Mars on the space agenda.

Experience in the many and varied study exercises performed since that time have shown the approach to be valid. Heinz H. Koelle, director, Future Projects Office, Marshall Space Flight Center, says manned Mars mission knowledge has increased ten fold since 1960—and also indicated a naive optimism was present initially.

Koelle says there is no pressure for an immediate decision committing NASA to a vast and expensive timetable resulting in an American on Mars. In fact, the space agency expert feels another five years spent in pursuing the current course of heavy paper analysis and some testing will lead to a good decision.

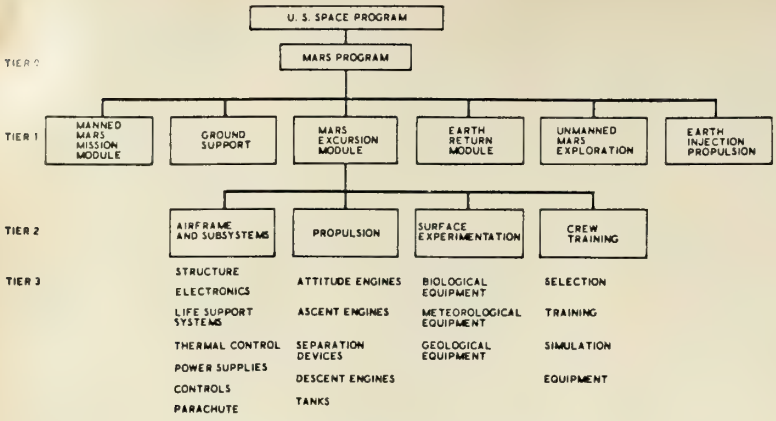
Koelle says the mid-1980's look good for a manned Mars landing from all viewpoints. There is a possibility of manned fly-by and orbit missions in the late 1970's, but Koelle admits the landing projection to the 1985 period does look hazy at the moment.

● **Optimistic realists**—There was a time when almost anybody would hazard a guess as to the total cost of manned Mars landings. Right now the only comment offered is that the effort will be significantly higher than the dollar involvement in the *Apollo* program.

There are concrete projections and cost analyses on record—derived from studies funded to industry and in-house work at the agency. But each is predicated on certain specific mission elements that differ drastically.

Those concerned with building a foundation of information designed to support and direct a decision to go to Mars are extremely reluctant to discuss details. This is one lesson learned through the experience of managing, coordinating and digesting the studies made over the past four years.

For instance, it was once thought that all manned Mars missions were dependent on the cycling of the Mars/Earth relationship in their respective swings around the Sun. Now the "bad" launch years have been significantly reduced by using the gravitational field of Venus in the transfer trajectories. This change in planning alone is indicative



CURRENT THINKING includes the use of a Mars Excursion Module to land men on the planet. A possible organization scheme illustrated here covers the areas of advanced technology necessary for the successful development of the landing module.

of the soundness of the study approach.

At the moment, Koelle says he is not ready to eliminate anything in the current manned Mars picture. There is not enough information for such a decision. There are degrees of attractiveness throughout all the proposed mission elements. There is no target year. There is no mission profile. There are a number of proposed solutions.

● **What is known**—There are several positive aspects in the area. For instance, it is technically feasible to predict fly-by, orbit and landing missions from an engineering standpoint. All will definitely start from Earth orbit.

All will depend on advanced technology, and this is one of the most difficult elements of the study programs since it is almost impossible to extrapolate technology beyond about five years with any degree of certainty.

All will depend on information gleaned from *Gemini, Apollo* and a host of unmanned space science probes.

And finally, the current thinking is that a nuclear engine is practically a necessity. This stage should provide thrust levels of about 250,000-lbs. NASA future planners are convinced that nuclear engine work should be sensibly pushed to the flight-test stages.

● **Earth entry**—The Venus swing-by technique may alleviate re-entry in that the extremely high entry velocities characteristic of the unfavorable launch period may be reduced to velocities associated with favorable windows.

But even a favorable launch window means an Earth-entry velocity of up to 42,000 fps. This poses problems in thermal protection quite beyond that being developed for lunar and Earth-orbit return.

Incorporation of retro-propulsion to reduce entry speeds carries an unacceptable penalty in overall gross weight.

● **Mars entry**—Direct knowledge of the Martian atmospheric envelope, including physical and chemical properties, would be invaluable to the design and cost of the Mars Excursion Module.

There is an associated need for data on the interplanetary environment to be traversed by any manned Mars mission.

All of this can be obtained through unmanned scientific probes to the vicinity of the planet. NASA planners are hopeful currently planned vehicles will carry such instrumentation.

The consensus is that such data is at least as valuable as pure scientific information with respect to adequate development of an overall space program.

● **Equipment life**—One of the most crucial interplanetary areas is the development and testing of electronic components, power sources and life-support equipment designed to last a minimum of 900 days. It is not generally recognized that the determination of reliability in this type of equipment will be a major expense.

Ground environmental testing will have to simulate as closely as possible the mission environment and time period. In addition, the mission environment is not defined to the extent that an economical components sub-program could be launched at this time.

While the *Apollo* missions and subsequent exploitation of the lunar and Earth orbit areas will contribute considerable information to component development, the extended operational lifetime demanded of equipment for even the shortest possible manned Mars mission is beyond that required for such programs.

● **Man himself**—There is no knowledge of the effect of long missions in space on the performance of a human being. Keeping astronauts alive is a mission complexity now.

Long-term effects of weightlessness is one prime example of human factors data gaps. Current studies include the creation and sustenance of some level of artificial gravity in manned Mars efforts. The need to know how much is needed or even if it is necessary at all places stringent constraints on all aspects of future planning.

The *Gemini* and *Apollo* programs will have some bearing on this, but neither of these currently keep man in the environment long enough to have a meaningful effect on Martian plans. Extended Earth-orbital programs will provide further weightlessness data.

● **A sense of timing**—How long would it take from the basic decision to develop to an operational vehicle on the launch pad ready to start the Earth-orbit phase? Current best guesses range between 10 and 14 years—with a minimum of 10 years no matter when the program started.

How soon could the program start is another major question. An intelligent decision cannot be made until more precise knowledge has been acquired. A specific example is space rendezvous.

COMPLETED STUDIES

Mars Excursion Module—Aeronutronic Div., Philco Corp., subsidiary of Ford Motor Co.

Mars Mission Module—North American Aviation

Mars Mission Re-Entry Module—Lockheed

Early Manned Interplanetary Exploration—General Dynamics/Astronautics

Manned Mars Exploration—General Dynamics/Astronautics & Douglas

Early Manned Interplanetary Exploration—Lockheed

STUDIES IN PROGRESS

Manned Mars and Venus Missions—General Dynamics/Astronautics

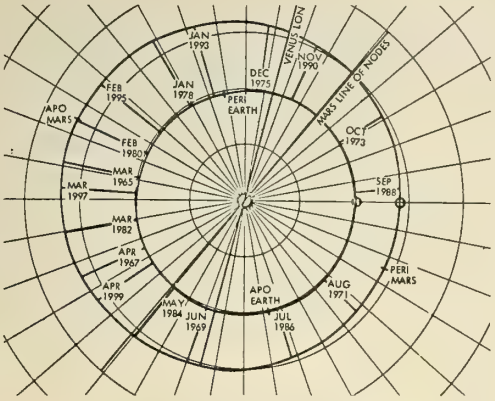
Mission Requirements for Manned Mars and Venus—General Dynamics/Fort Worth

Advanced Study of Conjunction Class Missions—Douglas

Manned Mars and Venus Fly-by—North American Aviation

Spacecraft Propulsion for Manned Mars and Venus Missions—Martin/Baltimore

Manned Mars Surface Operations—Avco



THE RELATIVE positions of Mars-Earth oppositions are indicated for two complete cycles covering 1971-1999. Venus swing-by technique increases usable launch windows.

All manned Mars missions begin with an Earth-orbit phase to re-fuel the mission vehicle. Rendezvous is an essential element. The U.S. will effect the first manned space rendezvous in the *Gemini* program.

The *Apollo* lunar orbit rendezvous experience is next. Most manned Mars suggestions incorporate a Mars excursion vehicle similar in principle to the Lunar Excursion Module—but with essential differences because of the presence of a Martian atmosphere.

The basic decision to go to Mars will probably precede an exact definition of the program by two to three years. In addition, because of the resources needed for a successful manned mission, the decision is of national importance. It will almost certainly have to be made by the President.

● **Solutions by the score**—NASA future planners have solutions for every problem currently visible in a manned Mars operation. The trick is not to get trapped in any one solution.

Dr. Franklin P. Dixon, director of Manned Planetary Studies at NASA Headquarters says that while "we know we can reach the solutions, we also know they will be expensive." And, at the moment, there is not enough knowledge in hand to optimize the costs.

The study philosophy at NASA is designed to keep a constantly freshened base of information ready to support a decision. This means constant reviewing of past efforts, planning new study areas and incorporating pertinent information from all of the agency's other programs into the manned Mars picture.

The cooperation and coordination throughout the entire agency is evident. In fact, even with the heavy *Apollo* commitment, Mars appears as the unofficial long-distance goal.

● **Covering all bets**—Precisely what will be studied with the coming fiscal year funding is not yet known. While NASA planners have a list of exploration areas, how much and how many will be undertaken depends on the available money.

The range of possible studies is broad. For instance, *Apollo* hardware could be used for an early manned Mars fly-by mission. The information gleaned would be invaluable for the ultimate landing mission. From this standpoint it makes sense to study the possibility —but this is not to say it will appear as a formal study in the next budget.

Just how effective such studies can be is evident from investigations into the Venus swing-by technique. This method has been described as "attractive" by NASA planners to the extent that its effect on previous efforts is being researched. Again, there are no indications that any Mars manned mission would actually involve such a technique. It looks good at the moment. That is as far as any NASA expert is willing to go.

● **Shifting windows**—Manned Mars launchings will be determined by the Mars-Earth oppositions. Launch opportunities precede these events by three to four months, and the window opens every 25.6 months.

In addition, the eccentricity of the Mars orbit changes the trajectory profiles from one opposition date to the next, which has a direct bearing on Earth re-entry velocities.

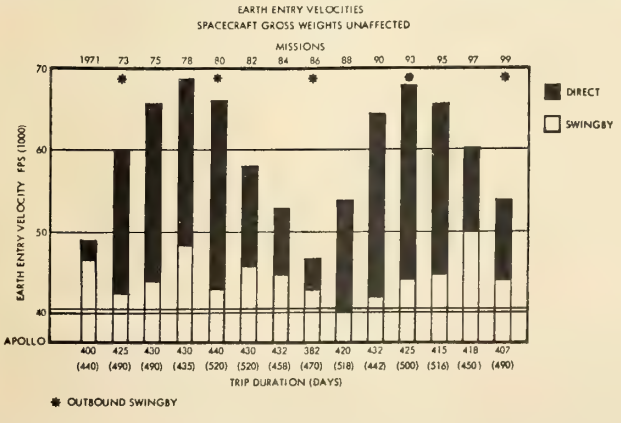
A favorable opposition such as that expected in 1971 means an Earth-entry velocity of about 46,000 fps. The most unfavorable situation—occurring in 1980—produces Earth entry-velocities up to 70,000 fps.

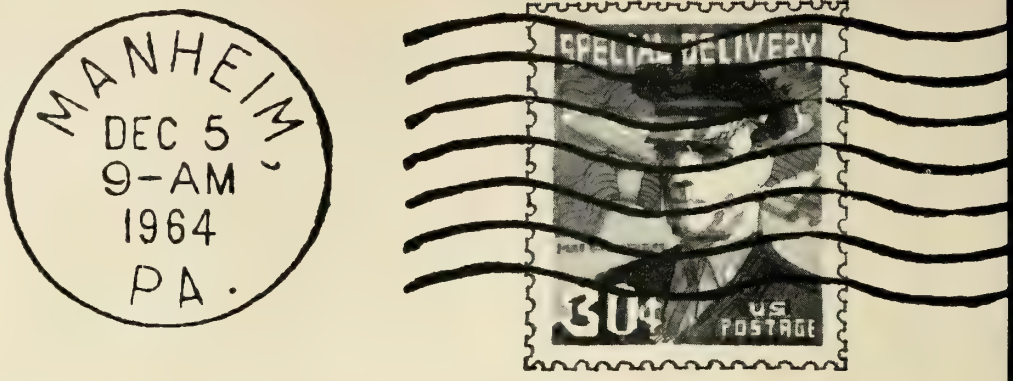
The pattern cycles every 15 years (every seventh opposition), and the manned mission profiles change accordingly.

● **Two approaches**—NASA's planning for manned missions can now be divided into two categories—direct mode or indirect mode. The direct route is relatively old in the history of the agency's study programs.

There are two general classes of direct-mode round trips to Mars—opposition-class modes with short stopover and conjunction class modes with an extended stopover.

SOHN'S RESULTS in applying the Venus swing-by technique to the 14 launch possibilities between 1971 and 1999 show a significant reduction in Earth-entry velocities.





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The opposition would have the spacecraft arriving and departing from Mars within a short period while Earth is between Mars and the Sun. The usual mission duration is between 300 and 500 days—the shortest Mars mission possible but the one demanding the most energy.

The conjunction mission approach would have the spacecraft arrive at Mars shortly after one of the opposition dates and depart just before the next opposition date. Mission duration is from 700 to 950 days, with a stay time on or near Mars of up to 500 days. This mission requires the least amount of energy.

The studies covering the short-duration Mars round trips generally indicate an optimum trip consisting of a short transfer to Mars arriving about 100 days after the opposition, and a long return to Earth. The total time varies between 400 and 440 days, with Earth entry velocities up to 70,000 fps in the unfavorable years.

● **Flight trajectories**—A typical mission trajectory path is made with the velocity vector nearly tangent to that of the Earth, minimizing departure propulsion requirements. As a result, the return leg is performed under unfavorable circumstances because Mars lags behind the Earth in heliocentric position.

The spacecraft must pass inside the Earth's orbit to develop an angular rate of travel higher than Earth's. Rendezvous with Earth occurs when the heliocentric radial velocity components are near maximum—resulting in high Earth-approach velocities.

The mission profile can be inverted, meaning that the outbound transfer leg takes the longer time. This mode involves a drastic increase in Earth-departure propulsion requirements. The alternatives in the short-duration mode would require accepting either a high Earth-re-entry velocity or a high Earth-departure speed.

The conjunction approach includes an extended stay in the vicinity of Mars or on the planet itself, but reduces the Earth-entry velocity demand while retaining the energy advantage of the opposition method in Earth departure and arrival at Mars.

In early manned Mars studies by NASA and its contractors, the long-term, conjunction approach looked extremely attractive. Today this method has lost much of its appeal because of mission conditions dictating other than optimum trajectories.

● **Gravity deceleration** — Another element recently has been brought into the general picture of manned Mars missions. This is the Venus swing-by mode in which the gravitational field of Venus decelerates the spacecraft. In the worst situation, a Venus swing-by will result in dropping the maximum Earth-entry velocity from 70,000 fps to around 50,000 fps.

Much of the detail examinations of this technique have been performed by TRW Space Technology Laboratories under contract to the Future Projects Office at the Marshall Space Flight Center. Robert L. Sohn, chief of the requirements staff in STL's Systems Research and Engineering Lab disclosed the Venus method at a recent AIAA/NASA meeting in Houston.

Koelle says this technique has changed trajectory parameters and looks attractive at the moment. The Venus swing-by also lessens the "good" and "bad" years problem originally set up in manned Mars studies. All NASA scientists involved in these studies emphasize that the studies are in their early stages.

Because one element appears promising right now does not necessarily mean a drastic shift in planning operations will come from it. In the case of the Venus swing-by, the situation is fluid. Development of the concept essentially proves the efficacy of the whole future study philosophy.

There are three reasons why the Venus swing-by technique is attractive in manned Mars mission planning. Sohn cites the first as being the fact that the spacecraft usually passes inside or near the orbit of Venus either on the return leg of the direct mode or on the outbound leg of the inverted approach.

Secondly, the gravitational field of Venus is strong enough to effect significant acceleration or deceleration by properly aligning the hyperbolic pass around the planet.

Finally, the angular rate of travel of Venus is large in comparison with Mars. This means Venus is usually available for use as a trajectory influence.

● **Stop-over applications** — Sohn chose a 1975 manned stop-over mission as representative of a typical unfavorable year for a direct return. In this case, the spacecraft would normally pass inside the orbit of Venus to effect an Earth rendezvous, reaching Earth at a relative heliocentric flight path angle of 31° and resulting in an Earth-entry velocity of 65,600 fps.

By adjusting the return trajectory slightly, Sohn says, the spacecraft can be made to rendezvous with Venus. If a darkside passage is made at an altitude of about 2,100 miles, the spacecraft's heliocentric velocity is reduced by 15,000 fps.

The resultant Venus-to-Earth trajectory approaches Earth at a relative heliocentric flight path of only 0.14°, and the entry velocity is then reduced to 44,000 fps from the original 65,600 fps.

The next obvious question is the applicability of the Venus swing-by mode to other Mars mission opportunities—especially those in the "bad" years.

● **Venus swing-by potential**—Sohn and his staff examined two cycles of opposition covering the period from 1971 to 1999. In many of the included 14 opportunities, the spacecraft does not pass close to Venus on the return leg.

But the angular rate of travel of Venus is rapid compared to Mars, and the spacecraft can remain in the Mars vicinity for a relatively short time and wait for a favorable rendezvous.

In addition, Sohn says the mission trajectory paths can be adjusted to effect a more favorable position for the Venus rendezvous—before or after perihelion passage of the spacecraft. About two-thirds of the missions can effectively utilize the Venus swing-by return to reduce Earth-entry velocities.

The remaining launch opportunities can take advantage of the Venus swing-by by inverting the trajectory—following long transfers to Mars and short returns. Normally precluded because of extreme Earth-launch requirements, the whip effect of Venus used on the initial transfer can reduce Earth-launch energy needs to near optimum values.

The result again is a reduction of Earth re-entry velocities to below 42,000 fps.

Sohn also suggests that Mars fly-by missions can also be handled through the Venus swing-by technique. Spacecraft arrive and depart Mars near the aphelions of transfer trajectories and move at relatively low velocity during the Mars passages.

This suggests, says Sohn, that the Mars stop-over missions previously described can be converted to fly-by missions through moderate-powered turns during the Mars passage. The gravitational field of Mars must be augmented by propulsive maneuvering.

Powered turns at Mars vary between 1,600 and 5,000 fps. Sohn derived these values by optimizing the turning maneuvers as to the time during passage, magnitude and direction of the incremental velocity addition.

Examination of the possible missions through a cycle of favorable to unfavorable opportunities indicates that velocity requirements with the Venus swing-by mode remain approximately the same.

In all of the analyses, Sohn says no penalties in propulsion requirements are incurred, although the total mission duration may be extended up to 20%. Communications distances are somewhat extended, but the navigation problem turns out to be no more difficult than with direct-mode passages.

Navigation propulsion requirements are increased by about 50%. ■

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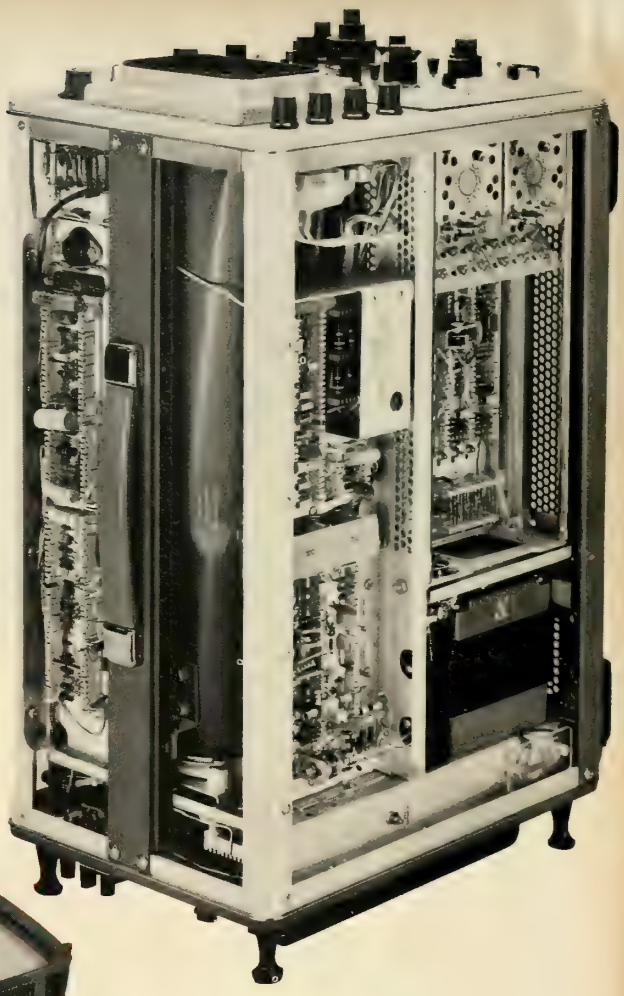
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Post-Saturn V Development Awaits High-Priority Manned Mars Effort

Follow-on seen as quantum jump from Saturn V, but details remain undefined; flexibility, economy get major stress; demand expected to lie more on technology than on development

ESTABLISHMENT of a manned mission to Mars stands as the only current reason for the development of a post-*Saturn* launch vehicle.

As long as there is no authorized, funded and high-priority manned Mars effort in being, the *Saturn V* launch vehicle system will be sufficient—at least for the foreseeable future.

Highlights of the advanced thinking going on in the various NASA offices include:

—The *Saturn V* and post-*Saturn* vehicles are not competitive. It is not a case of one or the other. The *Saturn V* will be an operational system for a long time to come.

—A major element in all advanced planning is a drive to get the most from the currently authorized systems in the national launch vehicle program.

—The *Saturn V* cannot be improved greatly, at least from the standpoint of cost effectiveness. In addition, the post-*Saturn* vehicle is now conceived as being a quantum jump ahead in all respects. No matter how the *Saturn V* is improved, this quantum step is not likely to occur in this system.

—The problem is compounded by the fact that the *Saturn V* has not yet flown. NASA future planners say it is somewhat premature to detail areas of improvement at this time.

—The post-*Saturn* vehicle system most probably will have one new characteristic—it will be reusable. Since reusability is something more than recoverability, it will have to be designed into the vehicle from the start.

● **Future plans hazy**—NASA has been studying the post-*Saturn* launch vehicle for some time. There is every indication this will be a way of life for several more years—unless a decision is made to initiate a manned Mars program sooner.

At the moment, no one knows what such a vehicle looks like, how large it will be, beyond certain lower limits on payload ability—or even how much it might cost.

There are intelligent guesses in each of these areas, however, and the nature of NASA planning is such that the agency will soon have enough information to start the early phases of such a program.

There is no pressure to make such a decision in the near future. In fact, the planners discourage any attempt to force them into even hypothetical situations at the moment.

The reasons for this are obvious. A nuclear rocket engine program is in progress—and is currently extremely successful. But this program is still in its early stages; much more information is yet to be gathered. This includes flight and early operational data.

Past experience dictates that any post-*Saturn* launch vehicle system will not be founded on a single-mission basis. Thus the burden on technology is greater than that posed by the development of the *Saturn V*. Reusability is not a state-of-the-art element. It requires development.

Studies do not advance the state of the art; only technology can do this.

● **Saturn uprating**—The largest effort within the launch vehicle section of the Future Projects Office at the Marshall Space Flight Center is centered around the possible improvements to the *Saturn* family of vehicles.

Better called a product improvement effort, this will remain in the study stage for some time to come. None of the improvements are expected to be incorporated into the *Apollo* program, but are rather aimed at post-*Apollo* operations.

All of these improvements are subjected to intense analysis, both as to cost effectiveness and as to efficiency. Mission inputs are extremely important. There is a strong attempt to live with existing facilities.

Many methods are available to get higher payload performance out of the *Saturn*. Higher-pressure engines, more efficient injection, pumping and other engine component improvements, together with fuel and oxidizer innovations can be cited as examples, but priorities change when cost factors are worked into the schemes.

This remains a study area. It is not known how the *Saturn* will be improved. There are still several major questions —such as whether a higher payload ability is as important as a more effective vehicle with the same payload.

● **Post-Saturn picture**—Studies into the future launch vehicle have served to focus and guide a broad front of technology within the entire rocket industry. Even though the vehicle cannot be defined, the exercise can set limits and indicate avenues of research. It already is clear that there must be an effort to keep the cost of such transportation down.

The complexity of the problem is best illustrated by Heinz Koeller, Director of the Future Projects Office at Marshall Space Flight Center, who says that defining a post-*Saturn* system is comparable to offering a single aircraft design to the airlines of the U.S. to serve all of their networks.

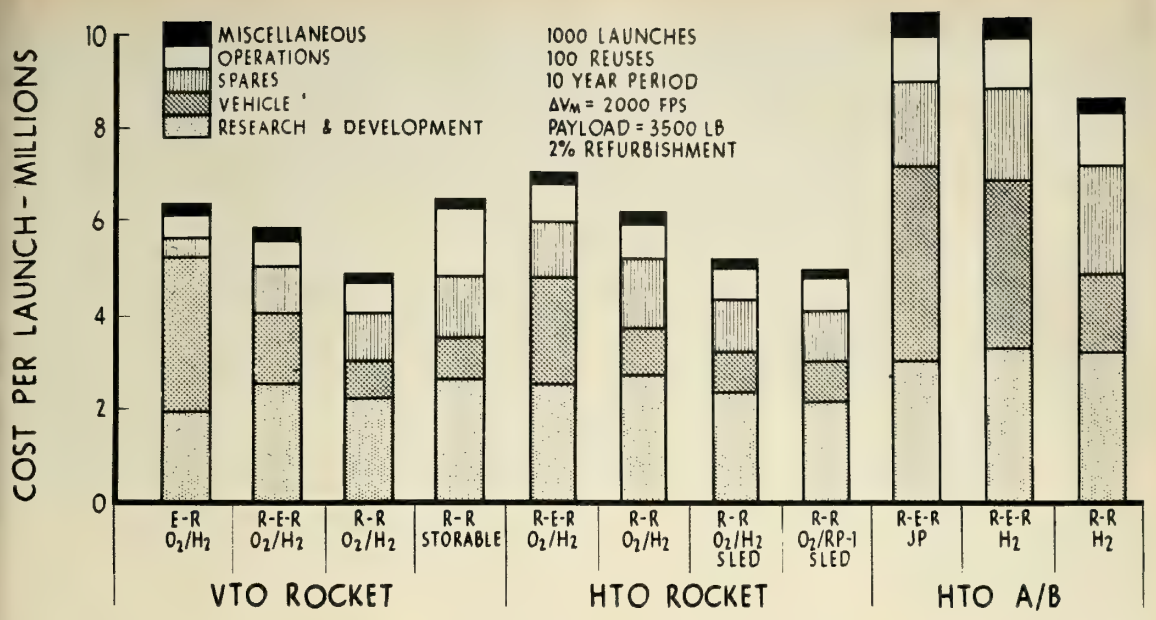


CHART REFLECTS results of Boeing Co. study comparing performance and cost characteristics of manned launch vehicles using vertical and horizontal take-off and horizontal take-off employing air-breathing first stages. This dominant cost summary illustrates difficulty of choosing a launch vehicle at the present time. Major costs appear in operations and R&D phases.

The vehicle cannot be designed on a single-mission basis but must consist of a group of alternatives optimized into a single family. Added to this is the knowledge that launch vehicle lead-time is extremely long—far longer than other elements of any mission. This carries a built-in danger of obsolescence.

NASA future planners have learned that planetary missions are by far the most demanding with respect to launch vehicles—thus, the intimate tie between manned exploration of Mars and the post-*Saturn* vehicle.

● **Unmanned launch plans**—The only new stage under discussion at NASA's Office of Space Sciences and Applications is a small upper-stage "kick" engine.

The unit is being studied for a primary application as an upper stage for *Centaur* vehicles. Its nominal thrust range is reported to be around 7,000 lbs. It may possibly be applied to *Agena*, *Thor* and *Atlas* launch vehicle systems.

V. L. Johnson, director of Launch Vehicles and Propulsion in the Space Science Office, says the stage may not turn out to be just a "kick" unit and its final definition has not yet been made.

Planning for other unmanned launch systems is as follows:

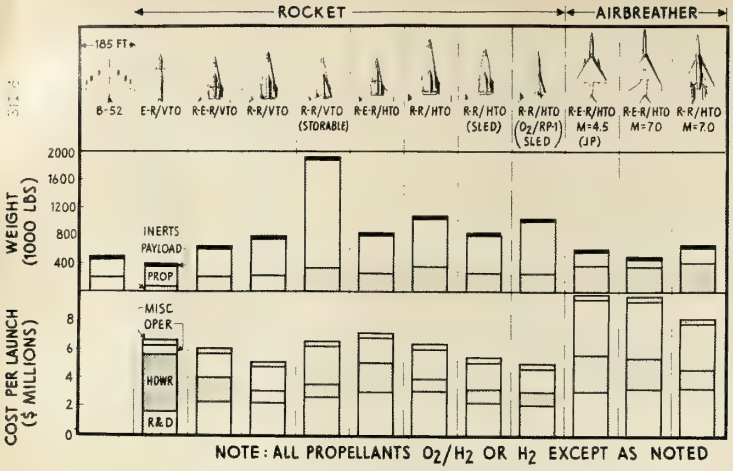
● *Scout*—NASA's lowest-price four-

TABLE 1. COST MODEL DESIGN INPUT VARIABLES (VTO Rocket 2-Stage, R-R/VTO)

INPUT VARIABLES	1ST STAGE	2ND STAGE
1. Number of stages per vehicle	—	—
2. Type of fuel per stage (liquids-solids)	O_2/H_2	O_2/H_2
3. Manning concept per stage	2	3
4. Re-usability concept per stage	Re-usable	Re-usable
5. Takeoff concept of vehicle	VTO	—
6. Landing concept	Horizontal	Horizontal
7. Thrust of each engine type (pounds x 1000)	500	175
8. Number of engines per stage	4	1
9. Total number of flight test launches	50	50
10. Total flight test engines required (each type)	8	2
11. Total flight test stages required (each type)	2	2
12. Total number of flight test instrumentation sets	2	2
13. Total successful operational launches	1,000	1,000
14. Total number of operational launches	1,109	1,109
15. Total operational stages required (each stage)	15	16
16. Total operational engines required (each type)	60	16
17. Total number of guidance sets	0	16
18. Total number of refurbishments	1,094	1,093
19. Material used in airframe	Al & Steel	Al & Steel
20. Number of launch pads required	2	—
21. Number of airfields required	2	2
22. Propellant weight (pounds x 1000)	482	120
23. Propellant volume (cubic feet)	24,100	6,000
24. Equipment weight (pounds)	9,400	5,500
25. Production rate, units per month	1	1
26. Refurbishment rate (%)	2	2

TABLE 2. TWO-STAGE (R-R/VTO) COST MODEL OUTPUT 100 Re-uses, 1000 Launches

	COST ($ in Millions)
R&D	
1st Stage airframe	289
2nd Stage airframe	275
Engines	425
Ground support equipment	188
Preliminary studies	150
Flight test	1,025
Subtotal	2,352
OPERATIONAL VEHICLES	
1st stage (with engines)	449
2nd stage (with engines)	154
Guidance and airborne equipment	104
Subtotal	707
OPERATION COSTS	
Spares	988
Personnel	545
Other	56
Subtotal	1,589
MISCELLANEOUS COSTS	
General and administration	81
Ground support equipment	126
Subtotal	207
TOTAL	4,855



BOEING STUDY summarizes the cost variations on a basis of 1,000 launched and a 2% refurbishment assumption. The similarity in overall costs from one concept to the next suggests to Boeing that cost variations may not properly be the primary consideration in choosing a vehicle. However, the wide variations in the cost elements per vehicle again underline the difficulty of defining a vehicle and committing such vast sums of money.

stage solid is just reaching its goal as a reasonably economical workhorse. There will be relatively minor improvements in the overall vehicle, but no major modifications are envisioned. The uprated *Castor* stage will be operational by the middle of 1965.

● *Thor-Delta*—The *Thrust-Augmented-Thor* (*TAT*) is considered to be "in the stable." NASA is funding the development of a larger *Delta* stage designed to significantly increase the payload ability of the vehicle. This should be operationally available in the fall of 1965.

NASA planners are considering bulding a *Thor-Delta* launch facility at the Western Test Range. This is being discussed with the Air Force; if the facility is authorized, it will be built in 1966.

● *Agena vehicles*—The *Agena D* or standard *Agena* is about to join the launch vehicle family. The next step is to mate it with the standard *Atlas*. The *Agena D* will also be used with the *Thor* as a standard vehicle.

● *Atlas-Centaur*—It is expected that a single-burn *Atlas-Centaur* will be operational in 1965. This vehicle is primarily designed for *Surveyor* missions in direct ascent to the Moon.

In late 1965 or early 1966, the *Atlas-Centaur* operational vehicle will include both the single-burn ability and the coast/restart mission area.

There is an improvement program involving the Pratt & Whitney RL-10 *Centaur* engine. This covers increases in both injector efficiency and nozzle expansion ratio. Any changes in thrust ability are secondary.

A continuing weight reduction program is in effect within the *Centaur* project. Applied to individual small items, its overall effect should be a lunar payload ability of 2,500 lbs. by 1967.

● **Other programs**—An effort in Flox technology is continuing through the current fiscal year. There still may be applications to the *Atlas*, but the work is chiefly concerned with the RL-10.

Pure fluorine and high fluorine combinations are being investigated, but there are no definite plans for a specific engine or stage.

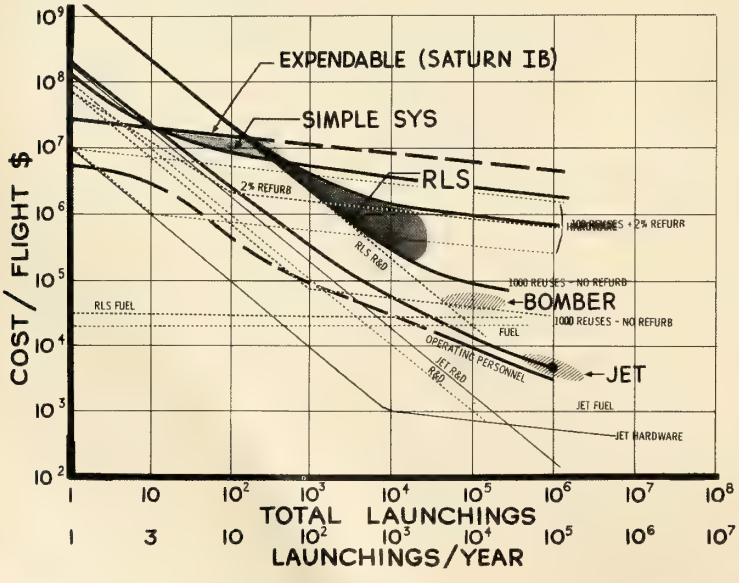
The *Saturn 1B/Centaur* is still under study at NASA as a primary launch vehicle for interplanetary unmanned probes. This is the vehicle being considered for the *Voyager* program. The combination is being examined for planetary applications in the 1969-1973 period with payloads in the 6,000-7,000-lb. class.

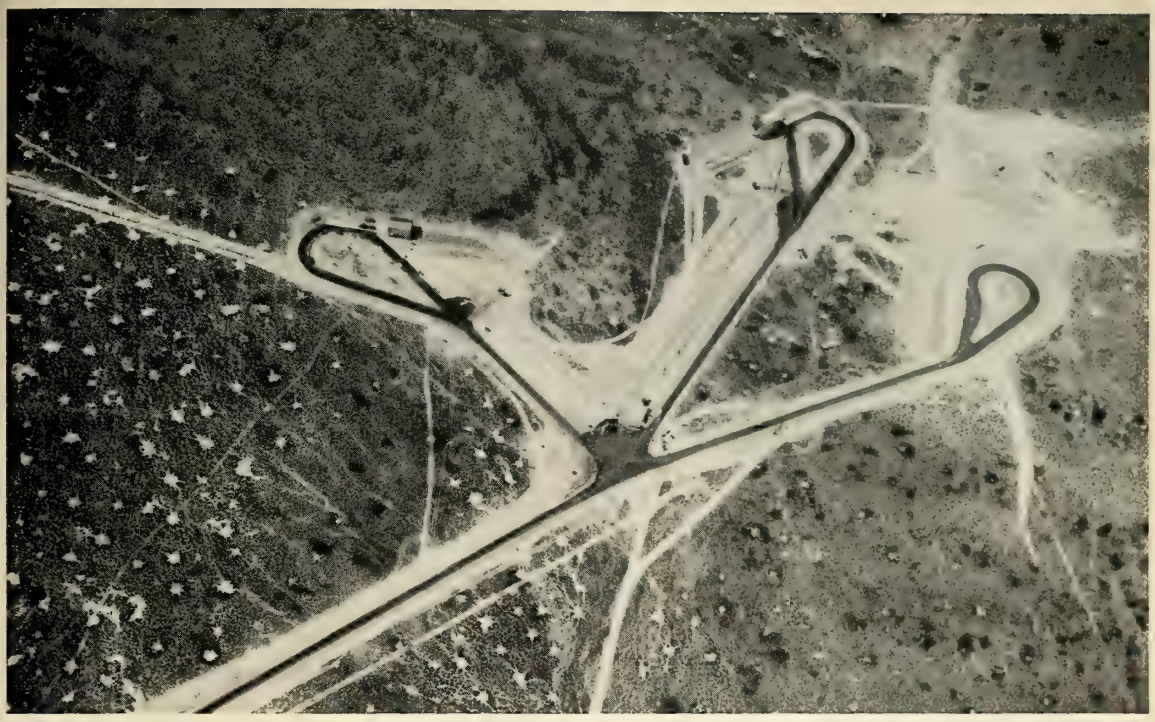
There is a joint study group composed of experts from NASA and DOD working out an agreeable solution for the *Saturn 1B* and *Titan III-C* third-stage problem. Both could use the *Centaur*, but the Air Force is pushing for a new engine based on F_2.

At the moment, space agency officials lean toward the *Saturn 1B/Centaur* combination over the *Titan III-C* because of the payload diameter difference—120-in. in the *Titan* and 260-in. in the *Saturn/Centaur*. The diameter is particularly important in the *Voyager* concept.

As for unmanned missions, the *Titan III-C* does not fit those currently in the planning stages at NASA. But Johnson is positive the *Titan* will be an active member of the entire U.S. launch vehicle family and probably will be used by NASA when the missions or payloads sensibly fit it. ■

THIS 7X8-CYCLE log-log plot covers the extreme range of $25 million per flight for Saturn 1B to $3,500 per flight for jet transports on the ordinate and from one launch a year in experimental launch systems to 100,000 flights per year for jet transports on the abscissa. The re-usable launch system data was superimposed on the chart. The general conclusion of the Boeing study is that advanced launch systems have large cost/effectiveness improvements over present systems.



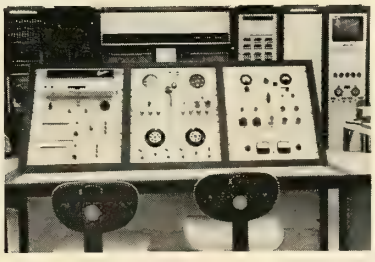


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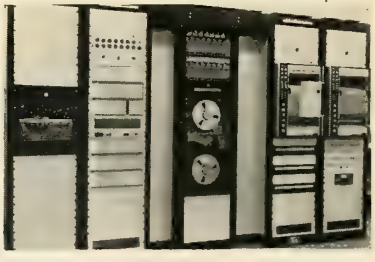
Pictured above is Hill Air Force Range, an airmunitions and propellant testing facility near Hill Air Force Base, Utah . . . now operational. F & M Systems' responsibility included conceptual and detailed design, fabrication, installation, and checkout of all instrumentation and control systems. F & M also conducted the first rocket motor firings and is responsible for training Air Force personnel. Among items to be tested are Minuteman and Genie motors and Mace and Bomarc boosters.



Note closed-circuit TV observing vertical and horizontal test stands . . . several angles of viewing motor tests and various phases of operation are provided. In fact, flexibility in all operations is evident. While the horizontal stand is proceeding with a motor test, the vertical stand is being made ready for test. Then, all data acquisition is switched to the vertical for test as the first stand is made ready again.



Close-up of a control console in the Central Data Recording Facility controlling all test areas. Vertical and horizontal stands are so completely instrumented that should a motor explode under test, extensive precision equipment could be ruined . . . therefore a third stand, known as the "hazard pad," is at hand as part of the vertical stand. Here, suspect motors are tested with only sufficient instrumentation to indicate what actually failed.



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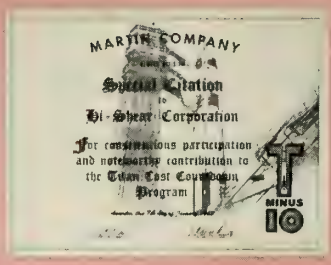
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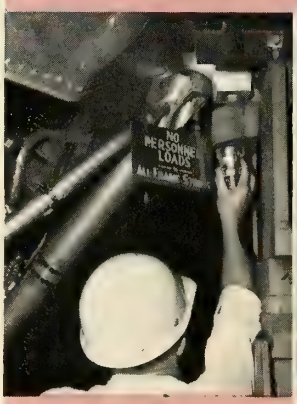
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A pair of 1¼ diameter Hi-Shear Separation Nuts used with a threaded stud at each of four attach points hold the Gemini-Titan launch vehicle to the launch ring. Each SN2121-10 Nut has a minimum axial tensile strength of 180,000 pounds and fully operates while under 130,000 pounds.



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U. S. AND FOREIGN PATENTS APPLIED FOR.

Phase I of Billion-Dollar Voyager Development Will Begin Next Month

1969 Mars mission and June '65 contractor selection hinge on approval of $20 to 50-million add-on to FY '66 budget; vehicle, either Atlas-Centaur or Saturn 1B-Centaur, dependent on amount

DEVELOPMENT of the unmanned *Voyager* planetary spacecraft will cost "just over one billion dollars," NASA estimates, for delivery of four flight articles through the first two Mars oppositions.

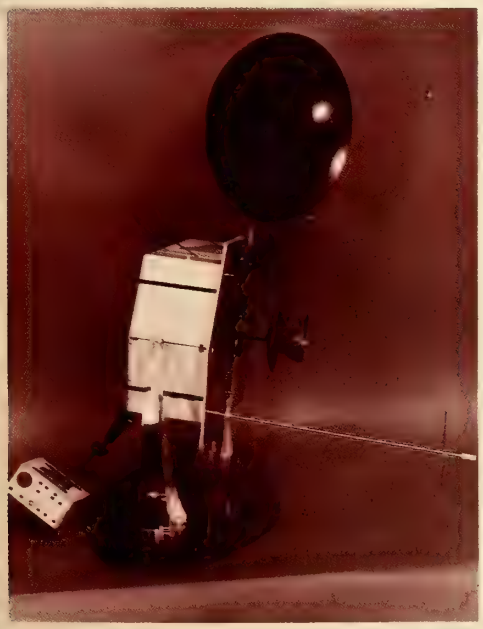
However, this would be just the beginning of a planetary exploration program which, in the 1970's, envisions the use of *Voyager* "to hit every Mars window and to bring Venus flights in as soon as possible," Edgar M. Cortright, Deputy Associate Administrator, Office of Space Sciences and Applications, said.

This would mean a minimum launch rate of two spacecraft per opportunity. Also, since *Voyager* will be adaptable to Venutian missions, further exploration of that planet could be undertaken if the funds and manpower were available.

Voyager is also expected to have a "potential beyond Mars and Venus," Cortright feels. Mercury, Jupiter, Saturn and missions out of the ecliptic are all attainable with present hardware —*Saturn V* with a high-energy, 7,000-lb.-thrust kick stage. However, he feels that "it is a matter of time and money before we get to them." *Saturn V* launch vehicles are not expected to be available to the space sciences program until the mid-1970's.

Further defining the word "potential," Donald P. Hearth of the Lunar and Planetary Programs Office pointed out that the technology from *Voyager* would be applicable to Venus and these other missions. "The only thing that would be tougher," he said, "would be the thermal control environment for a Venus mission, because the spacecraft would be going toward the Sun and would be subject to both solar and Venus albedo heating." Venutian landers would also be "considerably different."

For missions beyond Mars and Venus, Hearth feels that the same spacecraft cannot be used. But, since the problem of long lifetime components is the same for *Voyager* missions and those beyond *Voyager*, some of the





CONCEPT OF the Voyager spacecraft is shown in these pictures of the General Electric version. Two landers (right) would be separated from the bus as the spacecraft approaches Mars and propelled into an impact trajectory with the planet. The bus (left) would go into orbit around the planet. A large antenna would then be deployed for orbiter-Earth communications.

Advanced Mariner & Voyager Studies

AGENCY/FIRM PERFORMING STUDY	CONTRACTING AGENCY	DURATION	LAUNCH VEHICLE USED	LEVEL OF EFFORT (man-years)	REMARKS
Jet Propulsion Laboratory	—	May '62 to Nov. '63	Whole Range of Saturn Class	40	Parametric studies of Voyager mission with Saturn-class vehicles; finally settled on the 3-stage Saturn IB as the best launch vehicle.
Research and Advanced Development Div., Avco Corp.	Hqs	April '63 to Oct. '63	3-stage Saturn IB	60	
Missile and Space Vehicle Department, General Electric Co.	Hqs	April '63 to Oct. '63	3-stage Saturn IB	60	Awarded by Headquarters primarily to have separate studies, paralleling but independent of the JPL effort.
Lockheed Missiles and Space Co.	—	April '63 to Oct. '63	3-stage Saturn IB	25	An unfunded study which was a "real good job" and led to Lockheed's inclusion in later efforts.
Re-entry Systems Department, General Electric Co.	—	Oct. '63 to Jan. '64	Saturn V	?	"Project Beagle" study; also known as "Advanced Mariner"; unfunded.
Jet Propulsion Laboratory	—	Jan. '64 to Nov. '64	Atlas-Centaur (w/&w/o Flox)	20	Advanced Mariner for '69 and '71 missions using full Centaur vehicle capability.
Missile and Space Vehicle Department, General Electric Co.	Hqs	Apr. '64 to Dec. '64	Titan III-C & Saturn V	15-20	Follow-on to original contract; studied payload capability on either side of IB.
Research and Advanced Development Div., Avco Corp.	Hqs	May '64 to Nov. '64	Atlas-Centaur (w/ & w/o Flox)	30-35	Advanced Mariner flyby capsule.
Lockheed Missiles and Space Co.	Hqs	May '64 to Nov. '64	Atlas-Centaur (w/ & w/o Flox)	30-35	Advanced Mariner orbiter.

spacecraft's subsystems may be usable. In particular, the communications system and its 100-watt amplifiers, transmitting data at a lower bit rate, could be used as well as the Canopus star-trackers and the planetary horizon sensors. For missions beyond Mars, however, solar panels have reached the limit of their usefulness, barring a dramatic increase in cell efficiency.

● **Voyager: a new start**—No matter what the Budget Bureau's decision on the space agency's desire for a $20 to $50-million add-on to the Fiscal Year 1966 budget (M/R, Nov. 16, p. 12), NASA plans to initiate the *Voyager* development program before the end of this calendar year. Perhaps by mid-December, and most certainly before Jan. 1, industry will be asked to bid on the Phase 1, Preliminary Design Competition, for a "universal bus." This single procurement will cover the design of the spacecraft system and may involve several contractors.

Depending on whether there is to be a 1969 mission to Mars, there could be as much as a six to eight-month spread in the award of a development contract. If the $20-50 million is allowed, a contractor could be designated by June, 1965. If the decision is to forego the 1969 mission, the design competition would be stretched out, with the contractor not selected until the latter part of 1965.

Also to be resolved is the position of the Jet Propulsion Laboratory in the *Voyager* program. While it is planned that JPL will provide the technical management for *Voyager,* one approach would have the contract issued directly by NASA, with JPL playing the role of a technical director.

On the other hand, M/R was told by other headquarters officials that the request for proposals might come out of JPL and that the lab would manage the contract. Actually, they say, the decision "could go either way."

● **Mission profiles, 69-75**—Assuming that the Administration will allow NASA to conduct further planetary exploration with the *Atlas/Centaur* combination, the space agency would need an estimated $20 million additional in FY '66 to conduct a 1969 mission.

This might be a fly-by of the planet with as many of the *Voyager* components as possible and an instrument package originally proposed by a team of JPL scientists for the cancelled 1966 mission. The trajectory and the onboard data processing equipment will be chosen to enable simulation of orbital injection, which may take place in the 1971 mission.

The launch vehicle for the fly-by could be an *Atlas/Centaur* with approximately a 1,500-1,800-lb. payload. At the higher $50-million level, NASA would be able to conduct a fly-by *Voyager* test flight with the *Saturn 1B/-Centaur* and would thereby be in a good position to take advantage of the 1971 launch window—the closet Mars comes to Earth until 1986.

Of course, if *Mariner IV* fails, the space agency might get a go-ahead for a 1966 mission—and most likely would be allowed to conduct the 1969 flight. A 1966 mission would probably be a repeat of the fly-by launched Nov. 5 and the one scheduled for Nov. 27.

In 1971, the full *Voyager* spacecraft would be ready along with its launch vehicle. This mission would include both an orbiter and a lander, although the latter might not be a full-fledged vehicle. Lander weight would be approximately 1,000 lbs.

To a degree, the '71 mission would necessarily be a flight spacecraft qualification and carry instrumentation for this purpose. The orbiter would enable the study of season darkening on Mars but might not be capable of making a high-resolution survey of the planet's surface because of the altitudes at which it would fly.

A lander is to be used in 1971 to examine the fine detail of the planet's surface, said Robert J. Parks, Assistant Director for Lunar and Planetary Projects at JPL. This will not be a life-detection experiment, which will be delayed until 1973. Parks said he did not believe that planetary swingby techniques will change this schedule. The main limitation is funding.

Prime mission of the lander will be to investigate the Martian surface optically, with a visual resolution of fractions of a foot, and to measure surface wind velocity. Parks said this was likely to be an essential prerequisite mission before landing of a biological experiment on Mars to search for life.

Entry into the Martian atmosphere and landing, said Parks, could be carried out without getting better measurements than are expected from Earth-based telescopic observations and from the occultation experiment planned *Mariner IV*. "Your entry may not be as efficient as you would hope," he said, but in his view, a useful payload could be put down to determine the problems of landing a biological probe on the ground.

One of the atmospheric measure-

ments most required from a lander is determination of wind velocity, said Parks. There is no way to measure this with orbiters or simple atmospheric probes. Since wind velocities of 200 fps have been suggested for Mars, this measurement is of great significance for any parachute descent system. However, Parks said that for early capsules, a fast hard-lander, shock-protected by an envelope of balsa wood, could probably impact in a desired area without undue perturbation by wind.

Dr. William McDonald of JPL has suggested that the minimum payload for a lander would include measurement of peak entry deceleration, measurement of surface pressure, temperature and wind velocity and measurement of atmospheric composition by means of a mass spectrometer or gas chromatograph.

The '73 spacecraft would be essentially the same—with the exception that more weight would be put into the landers as the energy requirements for the orbiter increased. The landers would have a weight of 3,000 lbs. and could consist of two 1,500-lb. vehicles. Finally, by 1975, the energy requirements for putting the bus into orbit around Mars will be so great that the bus would fly by the planet; the extra weight would be put into the landers, boosting the weight of these vehicles to 4,000 lbs.

Mission planning of this type allows the orbiter missions to be accomplished at the earliest possible opportunity when the retro-propulsion requirements to put a spacecraft in orbit around Mars are at a minimum. At the same time, the lander weights will go up, increasing the amount of scientific instrumentation that can be put on the planet's surface.

● **Voyager spacecraft**—For the past two years, NASA, JPL and industry have been studying and defining the *Voyager* concept (see box). And, although these have been independent studies, they all had "an amazing amount of agreement," according to Hearth.

The spacecraft, as envisaged, consists of a bus with house-keeping functions, in-transit instrumentation and the orbiter package, the retro and mid-course propulsion system and the lander(s). Using numbers from the early studies, Hearth broke spacecraft weight down:

Bus (orbiter)—1,500 to 2,000 lbs., (100-200 lbs. science)
Retro-propulsion—2,500 lbs.
Lander (s)—2,500 lbs. (100-200 lbs. science)
Total weight: 7,000 lbs. (minimum)

These weights vary considerably depending on the mission to be conducted and the distance between Mars and Earth when it is flown.

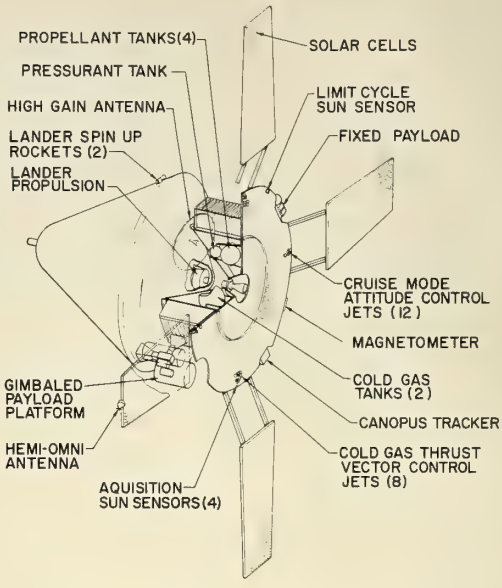
For example, the incremental velocity required to put a spacecraft into an elliptical orbit around Mars is such that, in a good year (1971), one pound of propellant will be required for one pound of payload in orbit. However, in a bad year (1977), as much as three pounds of propellant may be required for one pound of payload. Thus, with space-storable propellants and ignoring mid-course correction requirements, the bus-propulsion system weight can vary from 2,000 to 4,000 lbs.

This is also the reason that elliptical orbits are advantageous for Mars orbiters. It takes much more propulsion to circularize an orbit than it does to attain an elliptical orbit. A representative orbit for a *Voyager* orbiter might be 1,000 km periapsis and 30,000 apoapsis, although the periapsis might have to be increased to 4,000 km to insure that the unsterilized orbiter would not decay into the Martian atmosphere for 50 years.

The closeness of approach of the orbiter will be limited, as it must at all times have a probability of less than 0.0001 of hitting the planet. The orbit required at Mars is of about 45-degrees inclination and reasonably elliptical.

Hearth also points out that the stringent propulsion requirements are the reason that people run "hot and cold" on the role of the orbiter. Drawing a parallel with the lunar program in which the orbiting spacecraft is gaining an important role, he feels that, although the Mars orbiter is expensive in that it takes a lot of weight to accomplish the mission, this type of spacecraft is extremely useful. It can be used to conduct television reconnaissance and to measure the infrared characteristics of the surface, as well as to give data on planetary radiation belts and magnetic fields. "Orbiters *are* part of the planetary program," he emphasizes.

Another role which he feels orbiters can play—but one which is "a point for debate"—is as a communications relay between the landers and Earth. "In order to get a high data rate," Hearth says, "I think we're going to need a communications relay in orbit to eliminate the requirement for high-gain, directional antennas on the surface."



EARLY AVCO concept of Advanced Mariner with fly-by/bus-lander. With GE models (p. 81), illustrates Voyager evolution.

● **Requirements**—Orbiter/bus characteristics require that the spacecraft have a six-month lifetime and carry 150 to 200 lbs. of instrumentation. Over 200 sq. ft. of solar panel area will be required to provide the 500-watt power level. *Mariner* used about 70 sq. ft. of solar panels. Although there would be "important payoffs" in a hot-gas attitude-control system, all of the study contractors have recommended that a cold gas (nitrogen) system be used.

Large on-board antennas, 8 to 10 ft. in diameter, with very precise pointing accuracy, will be required. To illustrate the accuracy demanded, Hearth pointed out that a 4-ft. antenna has a beamwidth of 7.5 degrees, an 8-ft. antenna beamwidth of 4 degrees, and a 12-ft. antenna a beamwidth of 2.5 degrees. The *Voyager* antenna would have to be pointed toward Earth with an accuracy comparable to the bandwidth.

JPL has for some time recognized the need for an improved planetary horizon sensor and is developing (with Barnes Engineering) a 15-35 micron infrared tracker that will operate for apparent planetary diameters between 10 and 160 degrees. Uncorrected Schmidt optics and an array of vacuum-deposited bismuth-antimony thermocouples are used, each element looking out through a solid angle of 0.25 by 10 degrees.

The Celestial Sensors group of JPL's

Guidance and Control Systems Div. is developing an instrument to locate the center of a partly illuminated planetary disc and to measure its apparent angular diameter.

Retro-propulsion system will consist of space-storable propellants and the same engine will be used for mid-course corrections. Weight will run between 2,000 and 3,000 lbs. and the thrust level will be about 1,000-2,000 lbs. Some advantage could be gained by going to cryogenics, but the increase in efficiency is offset by the weight of the insulation required with cryogenic propellants.

Three mid-course maneuvers will be used during the interplanetary trajectory to reduce errors in orbiter-encounter position to a few tens of kilometers, said Dr. H. J. Stewart, chief of JPL's Advanced Technical Studies Office. He regards the DSIF capacity to measure perturbations in spacecraft orbits at interplanetary distances as sufficient to give accurate measurement of planetary position and so get around Mars ephemeris errors. He suggests, however, that an on-board abort system will be needed in case malfunction of the guidance system should make impact of the unsterilized orbiter on Mars likely.

Studies at JPL on the transfer from hyperbolic trajectory to the elliptical orbit have been concerned with coplanar approach and orbit. Inclination of the final orbit about Mars is adjusted by shifting the aiming point of the approach trajectory. Injection guidance similar to that used for *Mariner* mid-course maneuvers is under consideration.

In this, the pitch and roll angles are commanded when the spacecraft is in a known attitude in relation to the Sun and Canopus; then the motor burn is initiated through a predetermined thrust period, the spacecraft being held on course by an autopilot. JPL is currently examining the advantages of supplementing the autopilot with current information about the local horizontal derived from a planet-seeking device.

● **Landers, primary goal**—While orbiter and fly-by missions are important and are included in the program, the landers are the most important part of the *Voyager* concept. This is understandable. The most over-riding question concerning Mars is the existence of extraterrestrial life, and the landers are expected to provide an answer. To do this, however, four characteristics of landers must be fulfilled:

—*Large payloads:* Many of the experiments will consist of either one large payload or several complementary investigations.

—*Long lifetime:* In order to function over at least one Mars season (twice as long as one Earth season), which is considered a minimum to answer some scientific questions, the lander must have a lifetime of six months minimum on the planet.

—*High communications data rates:* Scanning television cameras and biological microscopes will require these high bit rates in order to yield worthwhile data.

—*Pinpoint landing accuracy:* Since the areas of more interesting investigation vary over the surface of the planet, the lander must be brought down in an area which will maximize the results from these expensive payloads. This will require a landing accuracy of $\pm$ 300-400 km—about the size of the more discrete areas of the planet.

The mission profile for the lander calls for it to be separated from the bus before the planetary encounter. It is then corrected to an impact trajectory by means of a small correction motor. When it enters the Martian atmosphere, where it is expected to experience between 150 and 200 g's, a parachute system lowers it to the surface. Since the atmosphere of Mars is estimated to be approximately 11 millibars, the lander will operate at a low ballistic coefficient (M/C_DA, typically 0.2 slugs/sq. ft.). As the planetary atmospheric pressure increases, the physical size of the lander increases and the amount of useful payload which can be landed decreases.

This, incidentally, is one of the prime reasons why NASA favors the *Saturn IB* over the *Titan III*. With the *IB*, the entire 260-in. diameter of the S-IVB stage can be used by shrouding the *Centaur* as well as the *Voyager*, thus relieving some of the constraints on lander size. With the *Titan III*, however, the base diameter of the vehicle is 120 in. and, although it could be hammerheaded, the shroud would present a more real constraint.

All of the landers will be sterilized through the terminal heat technique. This presents a problem requiring the use of heat-resistant components and complicates pre-launch ground operations. In addition, sterilization degrades the performance of some components, e.g. a battery subjected to the process loses one half of its capacity.

Radioisotope Thermionic Generators (RTG) will provide power for the landers. From 100 to 300 watts, either in several small units or one large generator, will be required. The contractors were unanimous in selecting the RTG because of its long lifetime and in spite of the fact that it creates some thermal control problems in-transit. Batteries were rejected on the basis of the continuous operation requirement over a long period of time. Beyond two to three days, the RTG becomes definitely superior to a battery system.

● **Voyager problems**—In addition to long lifetime and the reliability problems, major difficulties foreseen by NASA are in thermal control, communications, data storage and orbital operations. The greatest steps forward in the state of technology are required in the development of a 100-watt S-band power amplifier and the upgrading of tape recorder capabilities to storage capacities of 10^7 bits in the orbiter. Lander tape recorder requirements would be an order of magnitude less (10^6 bits).

JPL recognized early in its studies that the data automation system and data storage were the key to the interplanetary problem. Although the equipment needed for advanced spacecraft is not yet on the shelf, development has been sufficient to give JPL an understanding of how it would be produced.

Mariner III has a magnetic tape recorder capable of storing five million bits of information. JPL has also had developed under contract a recorder capable of storing 100 million bits of video information. The transport weighs 25 lbs. and is capable of record/playback speed ratios of 1,000:1. Power consumption in record is less than 20 watts. Tape speed can be adjusted to a number of values between 24 in. per second and 0.024 in. per second.

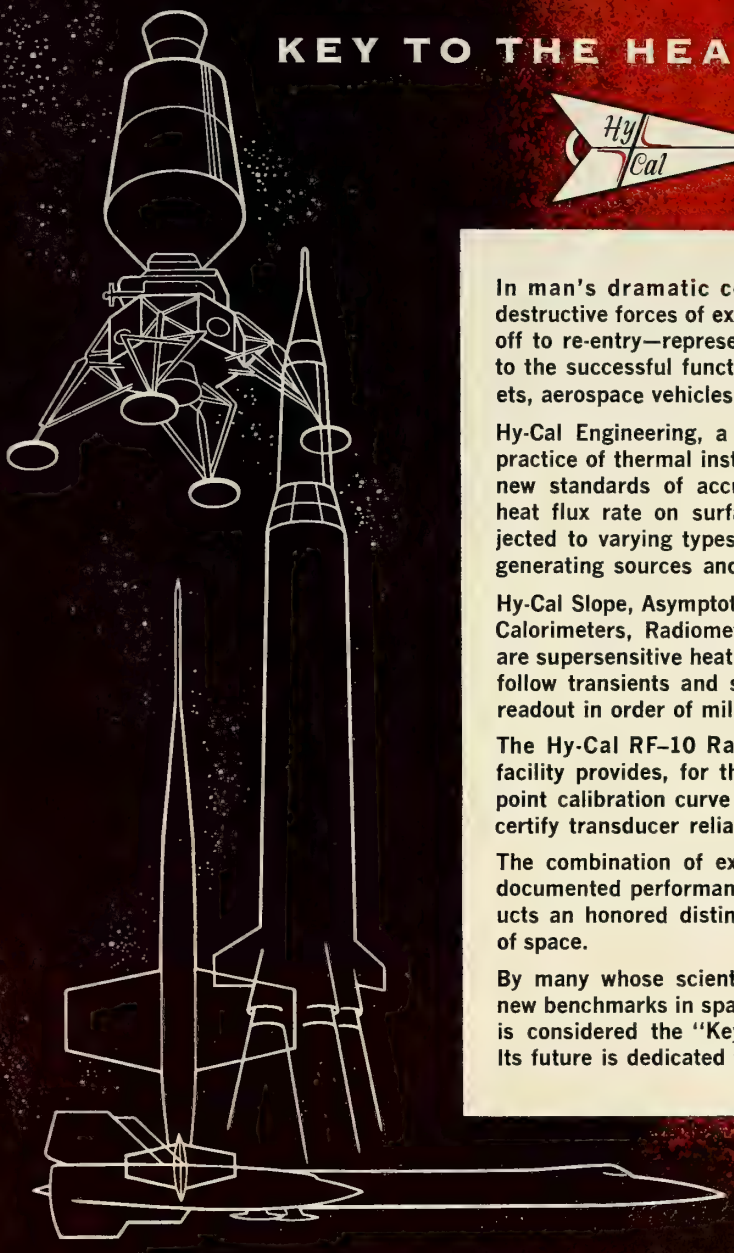
At present, recorders of this type have to be operated during launch to prevent the vibration causing tape spillage. Efforts are under way to get a synchronous recorder that does not need operation during launch, is capable of hard mounting and is lighter and smaller than present machines.

A study is being carried out at JPL to explore the feasibility of recording information at a density of 10,000 bits per linear inch, with 100 tracks across the width of normal one-inch tape. This will provide a packing density of one million bits per inch and reduce the 330 ft. of quarter-inch tape used by the *Mariner III* recorder to 10 inches of half-inch tape. So far, experiments have been carried out with 24 tracks on 0.25-in. tape.

A member of JPL said that techniques such as these may lead to a 10-million-bit recorder the size of a cigarette package.

The data automation system used on board the present *Mariner* is intended as a general-purpose instrument for use on future spacecraft. However, development of advanced data automation systems is continuing at JPL. One system uses a tape storage system able to take data at various rates from different instruments and record simultaneously on independent tracks. Data gaps of arbitrary length are allowable on the tape, the gaps being removed during buffered playback.

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At present, S-band power amplifier levels run at 10 watts—well below ultimate *Voyager* requirements. By the time the spacecraft is ready to fly, however, NASA expects that the higher power level will have been reached. Pointing accuracy of the antennas, as pointed out previously, will pose another difficult communications problem.

Even if the orbiter is used as a relay between the lander and Earth, it is felt that there must be direct communications between the surface vehicle and Earth. This will provide redundancy in the event the orbiter should fail prematurely.

In-orbit operations are expected to be difficult, but NASA feels that this is essentially a "software" problem. The Deep Space Instrumentation Facility will be used to track the spacecraft. The Central Computer and Sequencer (CC&S) will share this command function with the DSIF, but the CC&S will still be much more complicated than the ones used on *Mariner*. For example, there will be approximately three times as many CC&S commands on *Voyager* as there were on *Mariner*. This again is felt to be a software problem involving, specifically, a more difficult electronic design.

Finally, the payloads themselves present unique difficulties. Due to the tougher integration requirements, there must be a long lead-time on the experiments.

This means that payloads for a particular mission must be selected far in advance of a particular flight and without recourse to the *Voyager* payload of two years before. ■

Aeronutronic Weighs ABL Experiments

THE AUTOMATED Biological Laboratory (ABL) concept now being studied by the Aeronutronic division of Philco Corp. will determine the feasibility of large, fully integrated exobiological experiments. The study contract was awarded as the result of a "yell for help" by NASA to the aerospace industry, according to Benny B. Hall, Deputy Director of the space agency's Bioscience Programs Division.

As it became apparent that large launch vehicles in the *Saturn* class might be used in the unmanned planetary program, Hall said, many biologists began to feel that a large number of experiments should be landed on Mars to search for life. Substantial support then grew for the use of integrated payloads for this mission.

Unfortunately, however, the feasibility of automated laboratories for extraterrestrial life experiments is not at all clear. In fact, automated laboratories are not widely used in Earth-bound applications.

Therefore, Hall said, NASA decided it was time to "bring in some industrial experience" to study the problem. After evaluating proposals solicited from eight companies, it awarded the study contract to Aeronutronic in August of this year.

To run for twelve months, the study will cover the possibilities of common acquisition devices, samplers, and a common command sequencer. Also, the company is to investigate landing sites, taking into account the seasons of Mars and the time at which the flight takes place. Still further, Aeronutronic is to make parametric analyses of the advantages and disadvantages of single experiments, small payloads and the large automated type of laboratory.

The study is to be submitted in September of next year.

● **Small experiments**—Meanwhile, development effort on individual life-detection experiments is continuing and is being funded under supporting research. Included in this category are such individual life-detection devices as Gulliver, the Wolf Trap, Optical Rotary Dispersion Profile experiment, the Multivator and the combined gas chromatograph and mass spectrometer. All of these, as well as the J-band life detector on which it did some in-house work, are to be studied by Aeronutronic.

Basically, these small experiments look not only for life itself but more particularly for evidences of life. And almost all of them are aimed at the detection of the lower spectrum of life.

There are essentially three levels of experiments: those which look for the presence of critical compounds essential to life or its development, those which examine the form and structure of macromolecules, and those which seek the physiological evidence of life forms. Most of the devices under development now concentrate on the first two levels—particularly on the first.

One of the real advantages of an Automated Biological Laboratory is that it would be large enough to look for life or evidence of it at all three levels. For example, an ABL would carry a television set and microphones so that the gross aspects of life—rabbit-sized creatures running across the Martian plains—would not be missed in the search for micro- or macro-molecule life forms or compounds.

● **ABL difficulties**—One of the problems in the ABL concept is that it requires a great deal of experimental logic to feed the results from one experiment into another and finally to a successful conclusion. Re-sterilization of the ABL after an experimental sequence is also expected to be a very real problem. Even if a positive indication of life is obtained in a particular experiment, it would be necessary to repeat that experiment in order to verify the conclusions. This would mean that there would have to be some sort of internal sterilization cycle which would clean out the ABL to re-run a particular experiment.

Ignorance of the environment is still another major factor in the design of large life experiment payloads. In fact, the areas of ignorance—wind velocity, surface conditions and cosmic ray intensity on the ground, to name just a few unknowns—are so great that there is a growing feeling that perhaps biologists should not be the first to land on Mars. A payload designed to give answers to engineering questions might be more valuable.

The nagging fear that the planet may be contaminated by the first payload landed, however, presents a dilemma. This gives strong impetus to proposals for landing a large biological payload at the first opportunity. The theory is that, if contamination is going to occur anyway, it would be better to get as many answers as possible as soon as possible with a large experiment package.

Aeronutronic has recently solicited the opinions of 300 U.S. scientists on the question of the ABL. In a letter, Dr. Robert E. Kay, a biochemist and manager of the company's Biosciences Dept. said: "Of particular interest would be experiments which you feel should be performed on Martian life in order to obtain information useful in current scientific inquiry and as an extension of your own research interests."

"However, you will make a substantial contribution to this program by simply discussing with us the feasibility of the ABL concept and its objectives in regard to your own scientific specialty," he added. Replies to the letter are expected by December.

Beyond even the ABL in NASA thinking is a roving vehicle that would be able to move over the Martian surface, collecting and analyzing samples. This, however, is far from fruition. ■

Funds for New Spacecraft Expected To Be Included in FY '66 Budget

Intensive exploration of Sun emphasized in plans calling for six Extended Pioneer spacecraft, first of which is set to be launched during 1968-69 peak solar flare period

SPACE AGENCY officials expect to begin funding a new series of spacecraft for unmanned exploration of the Sun and planets in the next fiscal year.

The first project—*Extended Pioneer*—will be launched toward the Sun during the maximum solar flare period in 1968-69. Plans now call for a total of six spacecraft with the first funding expected in FY '66.

The spacecraft will be very similar to the *Pioneer* spacecraft now being developed by TRW Space Technology Laboratories. It will weigh—depending on its mission—from 400 to 750 lbs.

It will be followed by the *Advanced Pioneer*, which will ultimately be the first solar monitor spacecraft. Officials now hope to get program approval and some funding by FY '67. The plan is to launch one a year from 1972 through the end of the decade. In 1973, however, two will be launched.

For solar missions, the spacecraft will weigh 400 to 500 lbs. Preliminary planning calls for it to weigh 750 lbs. for anti-solar missions. Power requirements might be 200 to 250 watts. Solar cells will be used for some missions, but there is a definite requirement for radioisotopic power.

The new projects stem in part from a study by STL that indicated the *Pioneer* space probe intended for operation at distances of 0.8 to 1.2 astronomical units from the Sun can be modified fairly easily for an approach to within 0.5 au. The modified spacecraft, *Extended Pioneer*, thus trespasses into the mission originally envisaged for *Advanced Pioneer*.

As a result, the *Advanced Pioneer* program is being delayed. When it is authorized, *Advanced Pioneer* will survey the region between 0.3 and 0.1 au, and so will virtually be the *Solar Probe* spacecraft.

The STL study for the Ames Research Center examined the possibility of putting *Pioneer* closer to the Sun by use of the *Improved Delta* or the *Atlas-Fire* booster. With the second booster, the spacecraft can be put closer than 0.5 au and the modifications to the spacecraft would be relatively minor. Main changes are to the on-board power system and the thermal control system. There would be no change in the on-board communications system. The 210-ft. dish at Goldstone would have to be used for ranges greater than one million miles to exploit the trajectory to the full.

Studies are also in hand to examine the advantages of the outward mission for *Advanced Pioneer* and also to examine the scientific merits of going even closer to the Sun than 0.1 au. This latter is a very high velocity mission and requires a breakthrough in propulsion. Currently it is receiving very little attention. Ames is concentrating on *Advanced Pioneer* and pressing for it to become an approved program in 1967. The advent of *Extended Pioneer* has of course weakened the chances of this happening.

Ames has also carried out studies on a *Solar Monitor*, which would be an *Advanced Pioneer* spacecraft placed within 0.1 au of the Sun to view the segment of the Sun not visible from Earth. It would provide seven days advance warning of solar flares, to support *Apollo* missions. There is a possibility that this mission too might be carried out with *Extended Pioneer*, with a new payload.

● **Booster needed**—The three boosters that have received most study for the *Advanced Pioneer* mission are the *Atlas-Agena*, *Atlas-Centaur*, and the *Titan III-C*, all with a currently available solid rocket fitted as a final stage. The *Atlas-Agena*/solid can place a 400-lb. probe within the orbit of Mercury, and the *Centaur* and the *Titan III* can extend the penetration to 0.28 and 0.22 au. A *Saturn* booster with a high energy upper stage is needed to get within 0.1 au.

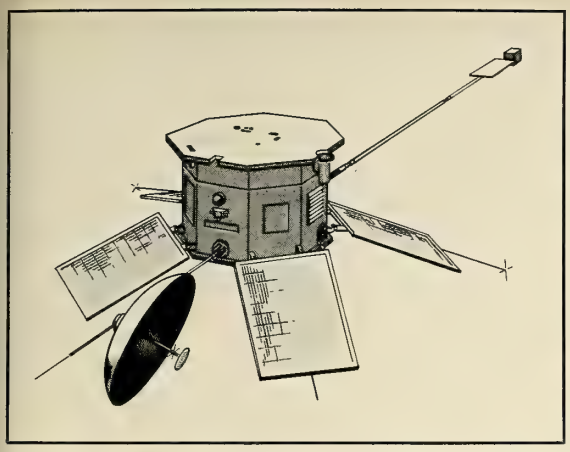
The same three boosters can put the same payload out to 4 au, 8.5 au, and nearly to solar system escape, when fired away from the Sun. A *Titan III-C*/solid could also put the 400-lb. payload 22 degrees out of the plane of the ecliptic.

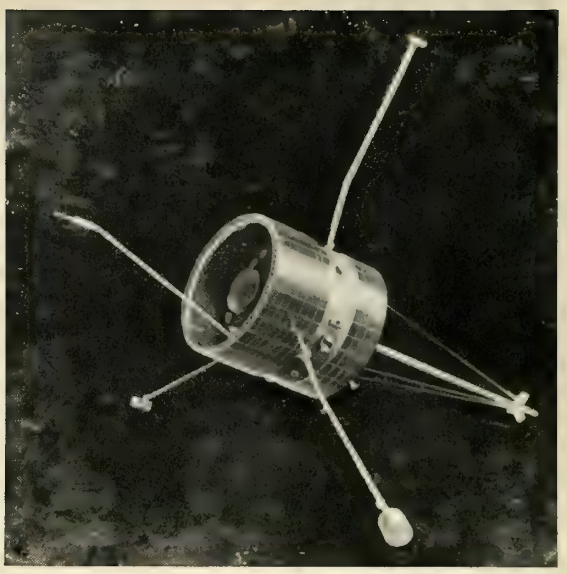
A conceptual configuration for *Advanced Pioneer*, to fit within the *Agena* shroud, consists of a closed box separated into two unequal parts, the upper and smaller portion next to the heat shield containing scientific instrumentation. The lower and larger portion would contain power conditioning equipment, communications and data handling system, and attitude control system.

The spacecraft would be three-axis stabilized, using Sun and Canopus sensors.

● **Equipment configurations**—Hinged to the bottom of the body are four solar panels that can be folded back during a solar mission as the spacecraft approaches the Sun, to prevent overheating of the solar cells. During an anti-solar mission, the cells can be folded forward toward normal incidence, as the spacecraft recedes from the Sun. For the anti-solar mission, double the panel area would be required and each panel would have a single fold.

A movable 4-ft. parabolic antenna extends from the body to provide the high gain link to Earth. Attached to the





ABOVE: Drawing of TRW Space Technology Laboratories' Pioneer spacecraft, technology for which will provide groundwork for later versions of NASA solar and planetary spacecraft, including the Extended Pioneer series of six. RIGHT: Conceptual configuration for Advanced Pioneer solar monitor spacecraft.

ends of two orthogonal solar panels are small omni-antennas. Antennas for an electron density experiment are located at the end of another solar panel and the high gain antenna.

Opposite the high gain antenna is a boom long enough to place the magnetometer in a region where the spacecraft-induced field is below one gamma. Mounted on the boom is a light thin plate to provide a solar pressure torque to counter that on the high gain antenna.

Mounted on the body face oriented toward the Sun is multifoil insulation designed to act as a thermal barrier to the heat flux from the Sun. The holes in the shield necessary for Sun-viewing instruments are kept as small as possible to keep heat input to a minimum. Appropriate coatings are painted on the body surfaces to maintain interior compartments between 0° and 40°C. Thermally actuated shutters are provided on two surfaces to fulfill requirements of both solar and anti-solar missions.

● **Early model Advanced Pioneer**—The earliest version of the spacecraft, to be launched by an *Atlas-Agena*/solid, should carry a payload of 60 lbs. of scientific instruments into about 0.35 au and communicate from there at 128 bits/second. For the anti-solar mission, the spacecraft could explore the interplanetary medium 1 au beyond Mars, within the inner region of the asteroid belt. Communication from this region would be at 16 bits per second. Beyond 2.5 au, the spacecraft would be too power-limited to communicate.

Use of the *Titan III-C* booster would put this spacecraft within 0.22 au of the Sun. Assuming use of an isotope power supply, the spacecraft could travel as far out in the solar system as the lifetime of its equipment would allow. For the outer mission, spacecraft weight can be increased to 750 lbs., and solar cell area can be increased fourfold. Solar power could be used out to 3.5 au. By suitable selection of trajectory, Jupiter can be reached in about 18 months and communication over the resulting interplanetary distance of 4.2 au could be achieved at 128 bits/second assuming a 9-ft. antenna and 40-watt transmitter tubes.

Perhaps the most significant point relative to the anti-solar mission, says Howard F. Matthews, Chief of Advanced Spacecraft Studies, NASA Ames Research Center, is that an isotope-powered *Advanced Pioneer* boosted by *Saturn IB* can explore the interplanetary medium beyond the orbit of Jupiter with reasonable mission lifetimes. The spacecraft would be 10 au from the Sun after seven years flight.

● **Far out funding**—Proposals have been made to NASA for missions to Mercury and to a comet, but the high cost of the Mars exploration program makes it unlikely that these will be funded until the latter half of the 1970's.

Undoubtedly, Mercury and the comets are extremely interesting objects for investigation. Their composition would throw significant light on the origin of the solar system.

By the latter half of the 1970's, the Jet Propulsion Laboratory expects to have an electrically propelled *Space Cruiser* that can deliver 500 lbs. of scientific instruments anywhere within the Solar System. The 20,000-lb. vehicle would be launched by a *Saturn IB* and would make use of SNAP 50/SPUR technology—a three-megawatt thermal nuclear reactor with boiler and turbine equipment serving a 20,000-rpm, 500-kw generator. Eighty per cent of the electrical power is used by the thrustors, which are expected to have specific impulse between 6,000 and 12,000 seconds.

Design goal for the entire spacecraft is a lifetime of 20,000 hours. This would give the capability of inserting an orbiter around Jupiter, putting a lander on Saturn, and making round trips to Mars and Venus.

A study made by JPL on the Jupiter orbiter considered a semi-axis of 1.5-million miles, and an eccentricity of 0.9, to give an orbital period of about one month and a closest approach of about 112,000 miles. Taking into account passage time to Jupiter, there would be a capability for two complete orbits about Jupiter, within the power plant lifetime.

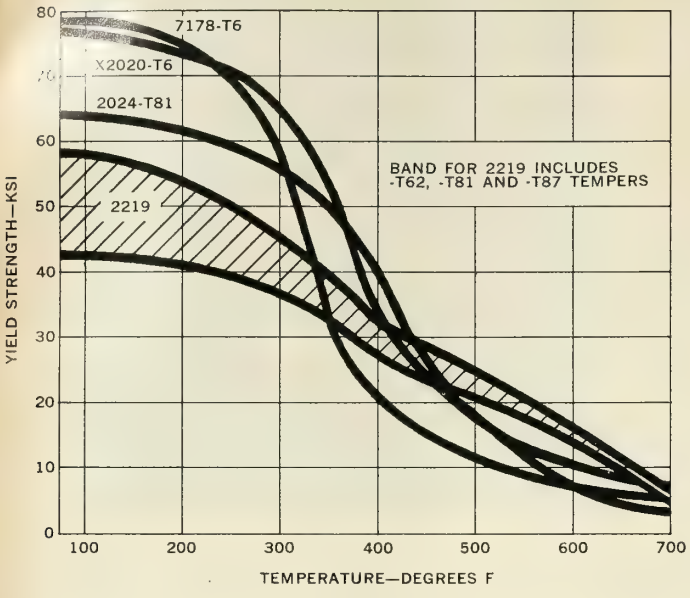
A major problem foreseen for the spacecraft is protection of the heat radiator tubes from micrometeorites.

Flight times to Jupiter and Saturn would be 630 and 930 days.

● **Pluto by 1984**—One mission that the *Space Cruiser* makes possible is a fly-by of Pluto in the 1984-5 period when it makes its closest approach to the Sun. At this time, it will be inside the orbit of Neptune. As Pluto takes 248 years to complete its orbit the opportunity to examine it at closest approach is somewhat infrequent. If this opportunity is to be taken with a chemical booster, it should already be on its way. Use of electrical propulsion provides a breathing space of some 15 years for development of the vehicle.

The *Space Cruiser* has also been suggested as suitable for intercepting Halley's comet in 1985-86—the "Comet Chaser" mission. This will call both for rendezvous and plane change and is an extremely high energy mission. ■

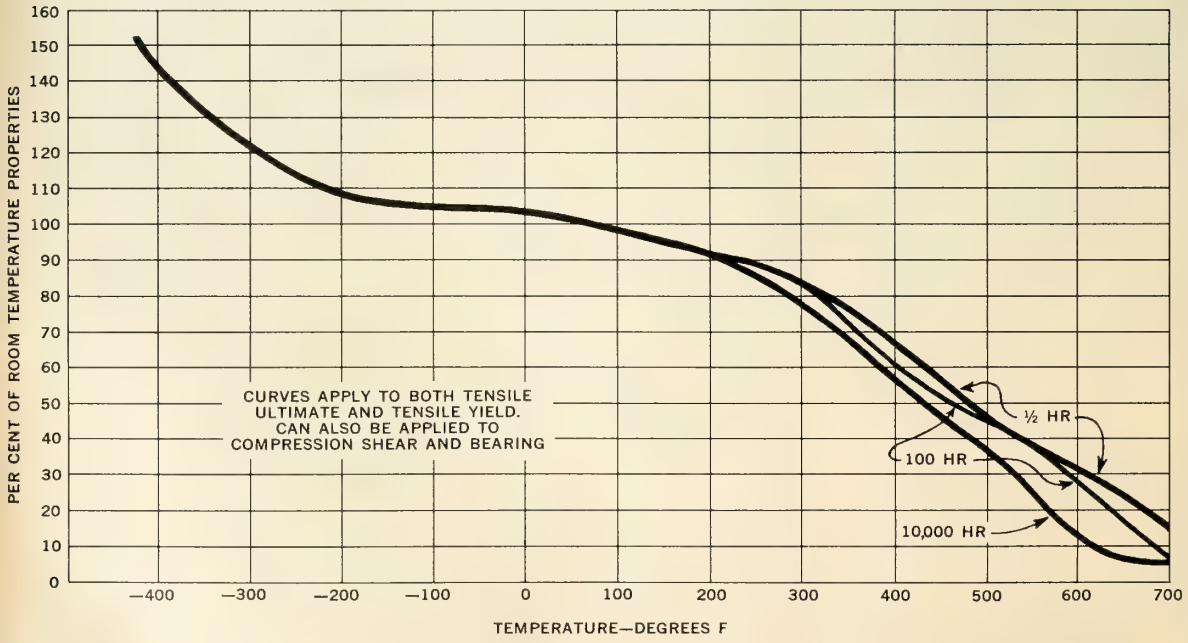
1. YIELD STRENGTH VS TEMPERATURE—100 HOUR EXPOSURE



2. TENSILE PROPERTIES OF WELDED 2219 AT —320°F

	Tensile Strength	Yield Strength	Elong. %	Notch Strength
2219-T81 or -T87 (as welded)	67,000	38,000	3.3	68,000
2219-T81 or -T87 (welded in -T31 or -T37, post weld aged)	68,000	46,000	2.0	65,000

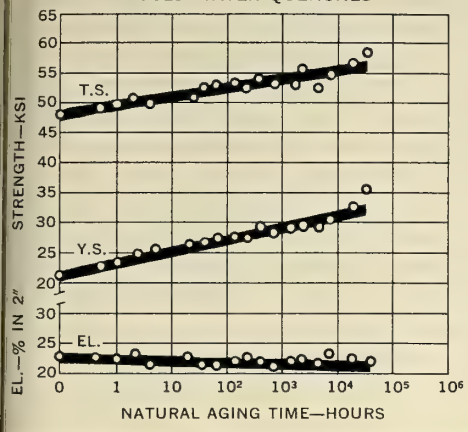
3. CHANGE OF MECHANICAL PROPERTIES WITH TEMPERATURE—ALLOY 2219-T81



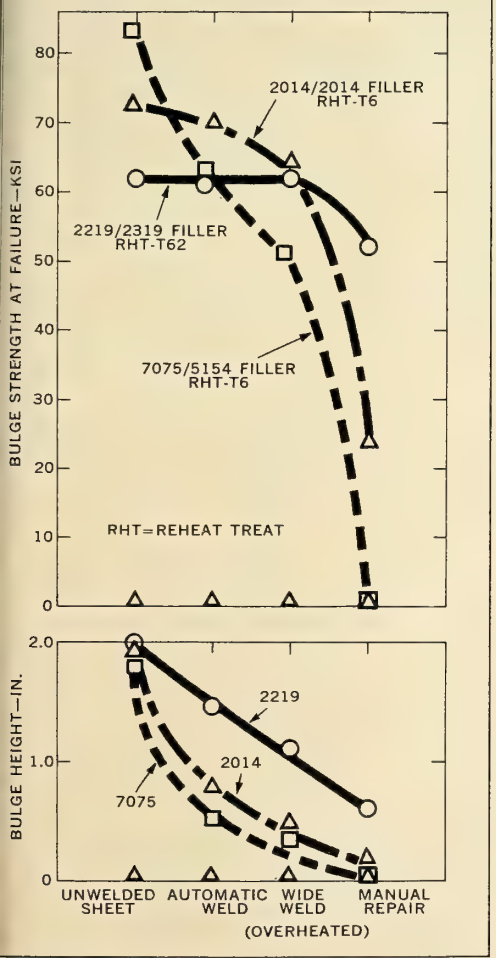
3A. TYPICAL ROOM TEMPERATURE MECHANICAL PROPERTIES

	Tensile Strength	Yield Strength	Elongation
2219-T87	69,000	57,000	10
2219-T81	66,000	51,000	11

4. NATURAL AGING OF 2219 ALLOY SOLUTION HEAT-TREATED AT 1,000°F COLD WATER QUENCHED



5. EFFECT OF WELDING CONDITIONS ON BULGE TEST PROPERTIES



ALCOA

Alcoa capability at work... gifted newcomer promises out-of-this-world performance on Saturn and LEM

What material did they pick for the Saturn 5 first stage? For the LEM (Lunar Excursion Module)? The designers' choice was 2219*, a new aluminum alloy from Alcoa.

Here's how alloy 2219 performs: It's the strongest conventional aluminum alloy in the 500-600°F heat range. At temperatures as low as −423°F, it has a tensile strength of 92,000 psi. It resists stress corrosion cracking and it gets along nicely with current fuels and oxidizers. It has good ballistic characteristics. Alcoa® Alloy 2219 is easy to work. Easier to weld. 2219 weldments also give good performances at sub-zero *and* elevated temperatures.

World's biggest light-metals workshop. It's Alcoa's. No other basic producer can match our facilities or knowledge. We can fabricate aluminum by any known method—rolling, casting, forging, impact, extrusion—we're not married to a single process. Alcoa's strong on research, development engineering and testing. Can you use our capabilities? Write Aluminum Company of America, 1027-L Alcoa Building, Pittsburgh, Pa. 15219.

*U. S. Patent No. 2,706,680

Radio Astronomy Explorer Program Approval Regarded as Imminent

Funds will come from FY '66 budget; Advanced OSO also expected to get full development money, but OSO may be retained as a solar monitor; OAO still on for 1965

NASA EXPECTS to launch six *Radio Astronomy Explorers* to investigate the lower end of the radio-frequency (RF) emissions from stellar sources. Program approval for *RAE* is expected shortly, and the effort will be funded in the Fiscal Year 1966 budget. Total cost of the program is estimated at $14 million.

Also, the *Advanced Orbiting Solar Observatory* is expected to move into full-scale development in the next Fiscal Year. NASA so far has funded the *AOSO* at a level that allowed only design refinement and some component development.

Even with *AOSO* scheduled to come into the solar physics program in 1969-70, NASA is seriously considering continuing *OSO* in the space sciences program as a solar monitor. The agency had previously planned some overlap of *OSO* with *AOSO*, but with the former phasing out as *AOSO* reached an operational status.

The *Orbiting Astronomical Observatory*, which is still scheduled to fly in 1965, will continue investigations of the ultraviolet spectrum through the fifth spacecraft. Emphasis is then expected to shift to the infrared region. Three flight spacecraft and their experiments have been authorized. Nine *OAO's*, carrying the program through 1974-75 are envisioned.

Other space sciences flight programs, including the *Orbiting Geophysical Observatory (OGO)*, the *Interplanetary Monitoring Probe (IMP)*, and the *Explorers* are expected to be continued well into the 1970's. Geodetic satellites, both active and passive, will also come into the program. Sounding rocket efforts are expected to continue at a rate of about one hundred launches per year.

● **RAE program**—First efforts in the *Radio Astronomy Explorer* program will be to investigate the RF spectrum in the frequency region of less than 3 mc. Below this, the ionosphere blocks ground-based observations, and in order to measure this region, the antenna must be placed above the ionosphere at an altitude of about 6,000 km.

Theory suggests that the intensity of the signal from stellar sources should drop off with decreasing frequency, but except for some limited measurements, this has not been proven. Dr. Frederick T. Maddock, Jr., of the Radio Astronomy Observatory, University of Michigan, has flown some instruments on sounding rockets to measure the radio sources at 0.5-2.0 mc. and experiments are being included on the *Eccentric-orbit Geophysical Observatory (EGO)* and *Polar Orbit Geophysical Observatory (POGO)*. However, *RAE* is needed for a systematic investigation of this frequency band.

The *Radio Astronomy Explorer* is a 280-lb. spacecraft, which, once in orbit, unfurls two 750-ft. V-antennas. The angle subtended by the V is ten degrees. The spacecraft will be launched on a *Delta* booster and will be inclined at 50 degrees to the equator. Goddard Space Flight Center is expected to build the first two spacecraft and industry the remaining four.

RAE is the "first beginning step in the program," Dr. John Naugle, director of Geophysics and Astronomy Programs said. Terming the spacecraft "crude," Naugle said that the next step would be to find some way to hook two of these spacecraft together so that an elementary interferometer results.

As to the direction of the radio astronomy effort beyond *RAE*, it is difficult to know, he said. It is likely, however, that the program will evolve into an observatory, since this has been the evolutionary direction of scientific programs in the past—from sounding rocket to explorer to observatory. At the higher end of the RF spectrum, above about 10,000 mc, a radio astronomy satellite would take a more conventional antenna shape. This would be a parabolic or dish-type receiver. Studies are under way to determine exactly what is required at the higher end of the spectrum.

● **University explorers**—Another program awaiting the approval of Dr. Robert Seamans, NASA Associate Administrator, is the university explorer. This is a satellite program to extend to scientists in universities, non-profit institutions and industry an opportunity to conduct space experiments. Essentially, the idea is to extend to orbiting vehicles the opportunities for experimentation that exist in sounding rockets.

These satellites, once the experiment is accepted, would be built by the experimenter or by NASA if he is not able to do the job. Launches of payloads up to about 200 lbs. on *Scout* boosters are planned. NASA estimates that the cost per experiment would run $3-5 million for the payload and launch vehicle.

One experimental payload has already been suggested and approved by various NASA officials through Dr. Homer E. Newell, director of Space Sciences and Applications. Eventually, the program would support a launch rate of about four university explorers per year. It is expected to take 3-4 years to achieve that rate, however.

This is as close as the agency feels it can come to the "payload allocation" recommendations of the space sciences summer study group that met at the State University of Iowa in 1962. This group had recommended that NASA set aside satellite space and power for an experimenter and allow him to fill it.

• **OSO and AOSO**—The cornerstones of the solar physics effort, *OSO* and *AOSO*, are emerging as complementary spacecraft rather than competing or one being a more advanced version of the other. The objectives of *AOSO* are to provide detailed studies of active regions of the Sun with a pointing accuracy of 5 arc sec.

The 1,250-lb. spacecraft will be launched into polar orbit and will therefore provide continuous coverage of the solar disc. *AOSO* also provides a tool for detailed studies of the ultraviolet and X-ray spectra of the Sun. NASA does foresee a requirement in the future for even finer pointing of instruments at discrete areas of the Sun.

With this fine-pointing accuracy, "it would not be a good use of *AOSO*" to use it as a solar monitor, Naugle feels. Yet, it is the radiation from the whole disc that determines the atmospheric heating of the Earth and the electron density of the ionosphere.

So it appears to make sense to use *OSO* as a solar radiation monitor while *AOSO* makes detailed analyses of the Sun. Launch costs for a monitoring *OSO* are estimated at $10-12 million.

A decision in this direction has not been made and does not have to be made for several years. The *OSO* program now extends through 1969 with a total of eight spacecraft planned. Only five of these, however, have been authorized—including one that has already been launched. Congress cut funds from the FY '65 budget that would have allowed procurement of the last three spacecraft.

• **OGO and OAO programs**—To continue at least throughout the next decade, the *Orbiting Geophysical Observatory* is expected to gain in sophistication of scientific instrumentation and also to take advantage of advances in spacecraft technology. NASA now has approval for six spacecraft and has contracted for five of them. The last of the authorized *OGO's* will be bought in the FY '66 budget.

Experiments have been selected for the first four *OGO's*, and a tentative selection of the majority of the payload has been made for *OGO-E*. Final selection of this payload, however, depends on results of experiments on *OGO-A*—now in orbit. A final decision on this payload is to be made in the first part of 1965, and a tentative selection of *OGO-F* experiments by mid-1965.

Present NASA planning calls for five more geophysical observatories beyond the present program. First buy on these spacecraft is expected in Fiscal 1967. Launch rate depends on the anticipated lifetime of the satellite, but basically the planning calls for one *EGO* and one *POGO* to be launched per year —with at least one of each operating in orbit at all times.

Although NASA plans to keep the spacecraft as standardized as possible, it foresees "somewhat individualistic" *OGO's* beyond the first four. This arises from the desire to tailor the spacecraft to the science and to progress to more sophisticated payloads to more adequately explore the Sun-Earth relationships. There are no plans to go beyond the *Atlas-Agena* as the *OGO* launch vehicle.

One possibility under consideration is the launching of an *OGO* spacecraft into a highly elliptical polar orbit for further exploration of the Earth environment.

NASA is still trying to hold a last quarter 1965 launch date for the first *Orbiting Astronomical Observatory*, but there are several development problems still to be completely solved. Primary among these are the star trackers and the Smithsonian experiment.

Six star trackers are used on *OAO* to point the spacecraft with an accuracy of 0.1 sec. of arc. These are the heart of the stabilization and control system and the spacecraft cannot be launched without them. As yet, no *OAO* star tracker has been fully qualified. Various components have passed qualification tests, but the entire star tracker subsystem has not. The main difficulty lies in the ability of the system to successfully complete the vibration test. There is a feeling, however, that *OAO* is close to a solution of this problem.

The other difficulty is in the Smithsonian Institution's experiment package. This experiment uses four vidicon tubes to map the sky in the ultraviolet. These tubes are the critical item. The problem is primarily in getting enough good tubes for the package. Rejection rate on tubes of this quality is extremely high, and therefore part of the problem is in producing enough tubes for various test units and flight experiments. The Wisconsin flight experiment package has already been delivered to Goddard. This is a companion experiment to the Smithsonian one.

NASA plans to ask for authorization to procure spacecraft four and five in the FY '66 budget. Launch rate for *OAO* is one every 12 months. Theoretical studies are also expected to get under way so that emphasis can be shifted to the infrared beyond spacecraft five. Experiments have not yet been selected for the final two ultraviolet *OAO's*.

• **Beefed-up Explorer**—one of the areas that shows promise for the future is the development of highly sophisticated *Explorers* for more difficult special missions. These payloads would be such that to fly them on *OGO* would be an inefficient use of that spacecraft and yet they would be important enough to justify launch.

To this end, NASA is exploring the use of microelectronics in the small special-purpose satellites to boost significantly the data rates obtainable. These satellites are visualized as weighing about 300 lbs. and able to be launched on *Scout* vehicles. It will be two to three years, however, before the space agency starts to develop these more sophisticated *Explorers*.

The approved program for *Explorers* is 25 spacecraft, broken down as: three aeronomy satellites, five ionospheric physics experiments, nine energetic particles, four geodosy and four international satellites. This carries the program through 1969. Beyond that, the *Explorer* program is expected to be sustained at an average of 12 launches per year.

• **IMP, continuing importance**—There are five, excluding the two now in orbit, *Interplanetary Monitoring Platforms* planned in the space program. There is every intention, however, to continue this program and to expand its possible uses. *IMP*, in a highly eccentric orbit, gives one point in space at which measurements of the cislunar environment can be made over a significant portion of the solar cycle.

This point, near Earth, allows correlations to be made between *IMP* results and those obtained in such programs as *Pioneer* and *Extended Pioneer*, which approach closer to the Sun.

In the geodetic satellite class, there are two programs under way. The first is *GEOS*, a 360-lb. active satellite based on the *ANNA* program. This spacecraft provides a triangulation point in space for determining distances and positions on Earth—a flashing light beacon for optical measurements and beacons for radiometric fixes. A corner reflector for laser experiments is also included. Two spacecraft are scheduled for launch, with the first planned for the last half of 1965. An improved *Thor-Delta* will be used for the launch.

The second geodetic program is *PAGEOS*—a passive satellite that can be skin-tracked. Two of these satellites are also planned. Each will be placed into a 2,000-km orbit. Measurements are expected to lead to a better understanding of three intimately related characteristics of the Earth: its ellipsoid, its geoid and its gravitational potential. ■

Advanced Technology Series, Possible NavAid Program Highlight Future R&D

Meteorological systems, dominant at present, will complement ATS development; latter project will cover 20 major experiments

INITIATION of the *Applications Technology Satellite (ATS)* series and the possible start of a *Navigational-Aid Satellite* program in Fiscal Year 1966 will comprise NASA's long-range R&D effort for the next decade in the fields of meteorology, communications, and NavAid satellite technology.

ATS is now in development. Providing up to 20 major experiments in both medium-altitude and synchronous orbits, the orbiting laboratories will contribute to each of the three applications-satellite programs.

Major emphasis in this field today is on meteorological satellite systems. Both *Tiros* and *Nimbus* will be used extensively to perform continuing experiments to develop hardware and techniques for at least the next five years, thus complementing future *ATS* missions.

APPLICATIONS TECHNOLOGY SATELLITE

SOMETIME in late 1966 or early 1967, NASA will launch its first *Applications* (formerly called *Advanced*) *Technology Satellite* aboard an *Atlas-Agena*. It will be the first of perhaps as many as five vehicles designed to test equipment and techniques for use in other satellites—in essence, unmanned orbital laboratories.

Directed by Goddard Space Flight Center, the program will strive to develop improved subsystems for meteorological, communications and navigational-aid satellites of the future. The total program, including three satellite flights, experiments and supporting ground systems, has been authorized to spend about $120 million. A decision will be made later concerning the need for two more vehicle flights, pending results of the earlier orbital experiments.

Hughes Aircraft Co., under a $37-million contract, will design, develop and build two prototypes and five flight systems, plus several engineering models for dynamic and environmental testing.

Looking much like an oversized *Syncom* satellite, *ATS* will measure 66 in. high by 59 in. in diameter and weigh about 700 lbs., without experimental packages and the apogee kick motor. The experiments will weigh from 150 to 200 lbs.; total expected weight, motor included, will be about 1,550 lbs.

The *ATS* payload ring will be quartered, thus permitting four experiments per flight, as well as test antennas and gravity-gradient booms. If five vehicles are employed, experiments break down as follows: communications (5); environmental (radiation) measurements (3); gravity gradient (3); meteorological (5); and four scientific packages not yet selected.

In addition to its vehicle responsibility, Hughes will develop the communications experiments for all flights that will be used to transmit wideband data to ground stations. Also, the firm will develop an electronic flight phased-array for testing.

The five proposed flights include three distinct missions: 1) the Medium-Altitude Gravity-Gradient Experiment (dubbed MAGGE); 2) two Synchronous-Altitude Spin-Stabilized Experiments (SASSE); and 3) two Synchronous-Altitude Gravity-Gradient Experiments (SAGGE).

MAGGE will be placed in a 6,000-mi.-altitude, circular orbit at a 28 to 30-degree inclination. All synchronous orbits will be equatorial. Launches will be roughly at six-month intervals from the Eastern Test Range and each *ATS* will be designed for a three-year operation in orbit. Thus, for at least some portion of the program, all five vehicles could be in orbit simultaneously.

- **Supporting ground stations**—*ATS* will require its own ground stations, located at Goddard's Rosman, N.C., satellite tracking complex and using an 85-ft. paraboloidal antenna; the Mojave, Calif., tracking station, using a 40-ft. dish; and at a site in the Pacific (either on Guam or in Australia), using a transportable facility with a 40-ft. reflector.

For the Rosman site, Westinghouse is integration contractor. Sylvania is developing the transportable station and Goddard included an option under this contract for system integration at Mojave. Raytheon will supply 10-kw, single-sideband FM transmitters.

Rosman will be the principal data collection point and will use a *Nimbus* processing center to direct meteorological data in real-time to Goddard.

All sites are scheduled to be operational by mid-1966. They will support all the experiments, evaluate multiple-access performance and verify FM modes of communications, and check a new Range and Range Rate system (contractor for this work is not yet selected, but the system will be designed for an accuracy of 1.5 meters in range, 0.01 meters per second in range rate).

- **ATS experiments**—MAGGE and SAGGE will be used to test a General Electric Co. gravity-gradient stabilization system at medium and synchronous altitudes. Booms will measure 100 ft. and weights will be varied.

TV cameras will be used to measure boom deflection and solar sensors employed to check attitude in the first two *ATS's*. In the next three spacecraft, different booms will be used and both infrared sensors and a simple interferometer will be used to determine accurately the perturbations in space.

Communications packages in all vehicles will be essentially the same. MAGGE will carry a dual-mode transponder (frequency translator) and a single sideband radio experiment. Actually, there will be one experiment for comparison of two modes—primarily SSB multiple-access performance capability. The system also will be used for telemetering other experimental data and will perform a Range and Range Rate function.

A ground linear accelerator (for the transmitter) is being developed for the SSB tests.

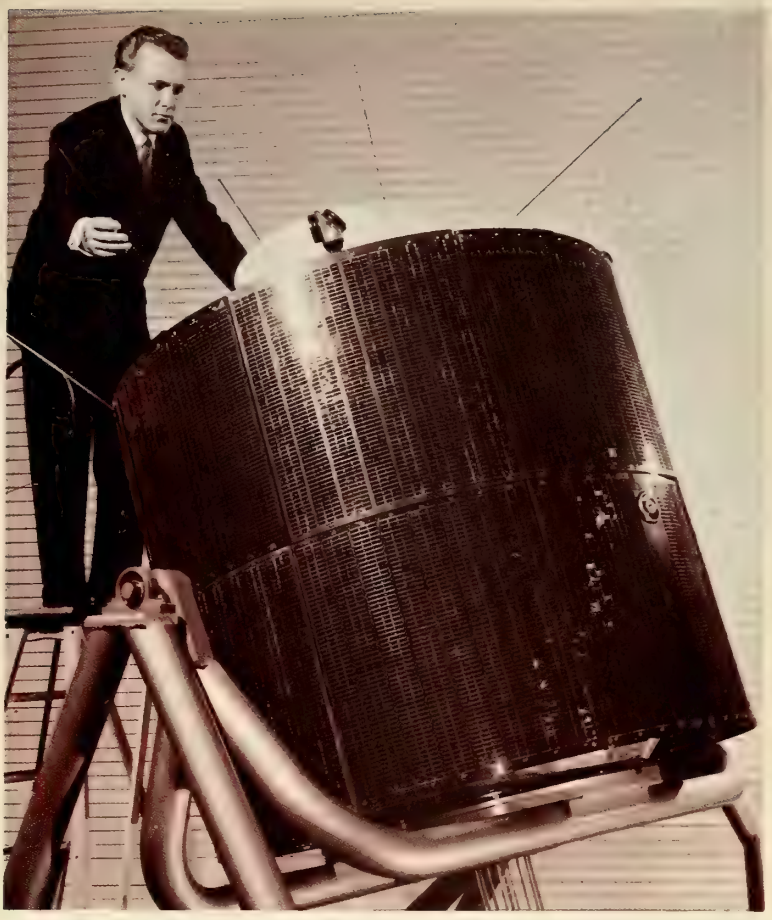
Unless an unforeseen problem arises, the same communications package will be used in each vehicle, but with different antennas. The spin-stabilized SASSE's will be provided with an electronically de-spun antenna and a mechanically de-spun antenna. The SAGGE's probably will employ a horn or dish-type antenna with narrow beamwidth.

Two goals will be sought with the meteorological packages in the *ATS* program: 1) obtain full-Earth-disc photos to determine the desirability of using a synchronous-orbit vehicle for meteorological applications, 2) determine the effect of meteorological systems on the gravity-gradient stabilization system.

The meteorological package in MAGGE will include two versions of the RCA *Nimbus*-type Advanced Vidicon Camera System (AVCS)—one lens will provide a full-Earth disc and the other probably will be a high-resolution assembly (0.5-1 mi.). The system will include a tape recorder for data storage until playback over the Rosman station.

Make-up of the meteorological packages for the SASSE's is still in doubt, but they will be the same in each vehicle. Image motion compensation will not be developed, but Goddard is considering use of a scanning system using vehicle spin and a rotating mirror for two-axis scan. A line scan camera probably will be used.

The SAGGE's are expected to employ two AVCS each, with 1-in. vidicon tubes. One spacecraft will carry a pair having one full-Earth disc lens and one high-resolution lens. The other will carry a camera pair using one full-Earth disc lens and one zoom lens. For the latter, a selectable-area, two-degree-of-freedom mirror system will be devised for use in front of the lens.



FULL-SCALE MODEL of new Applications Technology Satellite resembles an oversized Syncom. Under development for NASA's Goddard Space Flight Center by Hughes Aircraft Co., the 700-lb. vehicle is slated to be launched on its first flight in late 1966 in a medium-altitude orbit.

SYNCHRONOUS METEOROLOGICAL SATELLITES

BOTH *TIROS* AND *NIMBUS* meteorological satellites are expected to be used for some time by NASA as R&D vehicles. Present plans include up to 11 *Tiros*-type missions and a minimum of two *Nimbus*-type launches. But much of the advanced R&D will be centered on determining the practicality of synchronous-orbit Metsats.

RCA, Hughes and Republic last year completed studies of the approach. Several tests in space are now planned to provide more data. *Tiros-K*, for example, will be launched next year into a highly elliptical orbit with a 22,300-mi. apogee. This will provide nearly three hours of full-Earth-disc photo coverage, simulating that obtainable from a synchronous satellite.

In any event, a Synchronous Metsat development will not be pressed until experimental results are obtained from the *ATS* missions. The latter will not be completed until the early 70's.

Neither the need for nor the economic feasibility of a Synchronous Metsat has yet been demonstrated. Supporting 24-hour-satellite ground stations would be costly.

The advancement of Metsat data-collection systems is being pressed. High-resolution infrared cameras show promise, since they are capable of measuring cloud tops and heights. More studies are needed to determine the optimum portion of the spectrum.

Direct readout of infrared at existing APT (Automatic Picture Transmission) system ground stations may be possible, providing nighttime cloud-cover data. Goddard also is studying the use of an IR interferometer to provide a sweep across the spectrum for temperature profiles of the atmosphere.

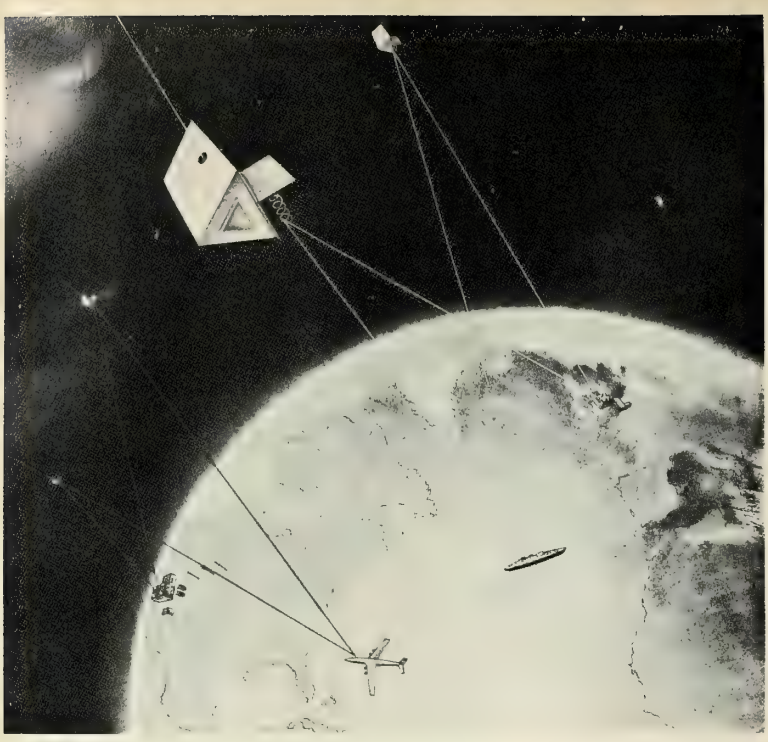
Bids from industry have been invited by Goddard for development of IRLS (Interrogation, Recording and Locating Systems). This approach involves use of a spacecraft receiver to operate with remote ground and possibly atmospheric sensors to collect local weather inputs for re-transmission to other meteorological data-receiving centers. *Nimbus-B* may be employed to test such a system.

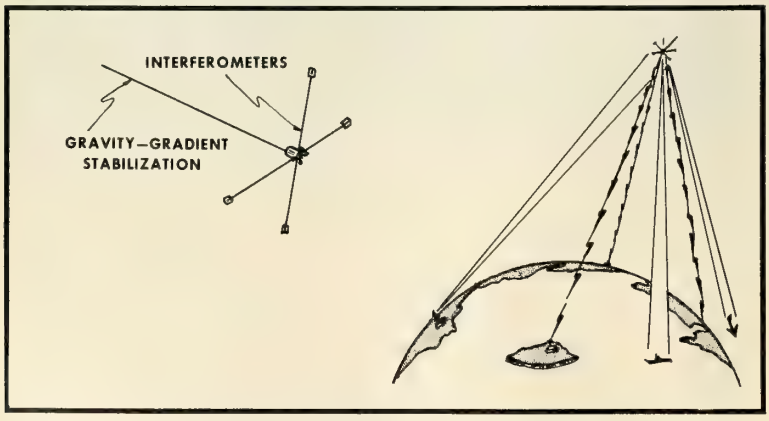
Data could be included with APT system photos to complete the identifying information presented: time, location, orbit and look angle. With such composite data, local forecasting station efficiency could be significantly improved.

Another approach being considered is loading a Metsat with ground-processed data for global sharing of weather data, thus reducing the present communications overload.

SATELLITE COMMUNICATIONS PROJECTS

GODDARD'S PRESENT efforts in the field of satellite communications





TWO PROPOSED NavAid Satellite approaches are being studied by NASA. TOP: General Electric would employ 16-24 paired satellites at medium altitude, using a pulsed repeater technique for position determination. BOTTOM: Westinghouse would utilize as many as five synchronous-orbit spacecraft and an interferometric approach for range and angle measurements.

technology are primarily associated with general techniques and specific hardware development for a 24-hour orbit capability.

The program began with *Syncom* development and moved to development of a five-year-operating *Advanced Syncom*, but the emphasis changed with the creation of the Communications Satellite Corp.

NASA has a broad mandate to develop and keep up with state-of-the-art technology in the field, but it is no longer attempting system development. It has demonstrated satellite communications between large terminals. Goddard will next initiate small-terminal studies and determine what techniques are needed. These investigations will seek to determine small-station power capabilities, aiming and concentration of RF energy, and multiple-access techniques.

NASA expects to do some work for the ComSat Corp., and it will support DOD in its military communications satellite program. Goddard is currently involved with DOD in a $5-million gravity-gradient test project. The Air Force will provide the test vehicle and NASA will monitor the experiments.

NAVIGATION-AID SATELLITES

A YEAR AND A HALF AGO NASA began looking into the use of satellites for a non-military global navigation-aid system to assist aircraft and surface vessels. Two early study contracts performed by General Electric and Westinghouse proved system feasibility.

It was also determined that by increasing the communications capability in such a Navsat system, international aircraft traffic control might be better effected. The most urgent need is for North Atlantic coverage; however, the system contemplated would have a global capability.

Two principal systems would be required: a lightweight, reliable instrumented satellite and a ground computer complex to process and support traffic control. Possible approaches already proposed to NASA are numerous, but two appear dominant.

General Electric has recommended a medium-altitude (6,000-mi.) system employing 16-24 satellites for early implementation of an operational system. Its ranging approach would require the use of two satellites, at any given time and location, to relay position data to and from the vessel or aircraft and the control center.

The Westinghouse approach calls for at least five satellites in synchronous orbits to provide complete Earth coverage. Three would be geostationary, 120° apart, and the other two would cover the polar regions. A single satellite, Westinghouse suggested, could cover the North and South Atlantic if it were located at about 33°W longitude.

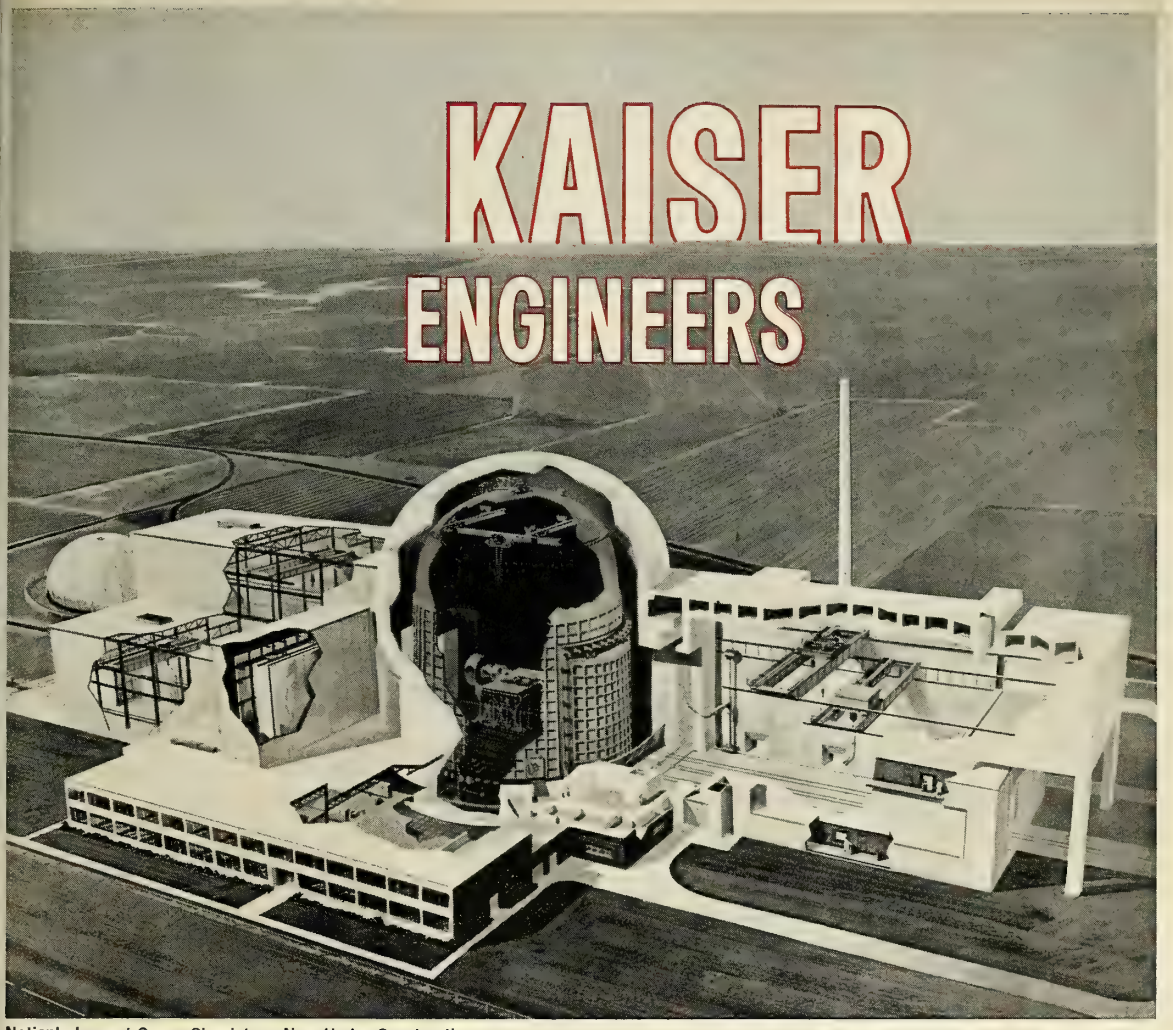
Each vehicle would be provided with two long-extended interferometers capable of providing range and two angles for position determinations. It, too, would communicate as a two-way relay between control center and vehicle.

Both systems would provide a 1-n.mi. accuracy in latitude and longitude.

An ad hoc Joint Navigation Satellite Committee has been created to represent potential users—the Commerce Dept., Interior Dept., Treasury Dept., and Federal Aviation Agency. Temporary chairman is Leonard Jaffee, director of NASA's Communications and Navigation Program division, Office of Space Sciences and Applications.

Under the present agreement, all organizations will pool information, determine requirements, and compare system approaches. The study, initiated in October, is scheduled for completion by next summer.

Present plans call for a program-definition-phase contract award in FY '66, if the report is favorable. ■



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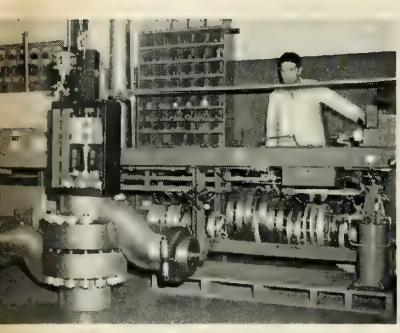
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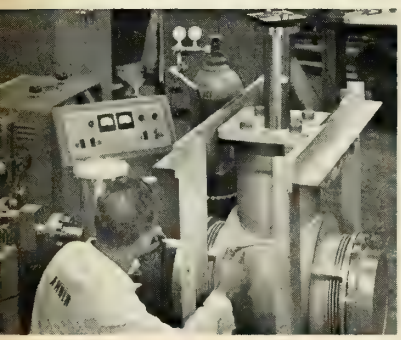
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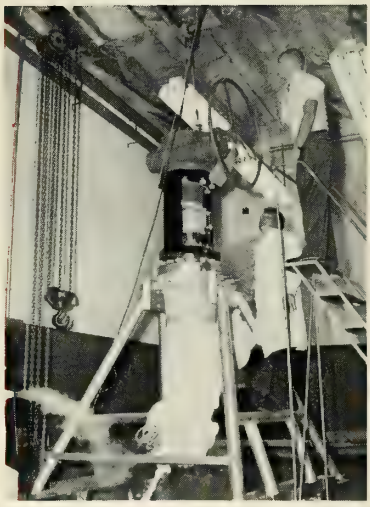
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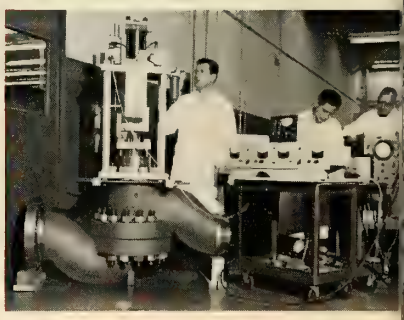


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Engineering Technology Satellite Among Four New OART Flight Programs

Martian entry, orbital scanner, high-speed RAM also under study; environment testing to move out of simulators into near-Earth orbit; low-thrust engines getting new emphasis

SEVERAL IMPORTANT new flight programs are now under study within NASA's Office of Advanced Research and Technology, an indication of the coming push by OART to graduate testing of future space systems from the chambers and simulators into the real environment of near-Earth orbit.

Virtually all of these programs will have an important bearing on OART's contribution to post-*Apollo* projects. Included among the flight programs, all of which may get initial funding in FY'66, are:

—*An Engineering Test Satellite*—This will be designed to provide OART with its own orbital test-bed to operate a very broad range of new space system experiments and equipments not necessarily linked to specific projects—such as will be the case with systems tested aboard the Office of Space Science and Application's (OSS&A) *Applications Technology Satellite*. This latter satellite was originally known as the *Advanced Technology Satellite*. Observers feel that *ETS* has a good chance for initial study funds in FY'66, but may have to wait for the FY'67 budget for the major development effort.

—*A Martian Entry Program*—Suggested as a logical first step to a Mars landing, this project would call for development of a new entry vehicle and new instrumentation. It would be flight tested using the upper portions of the Earth's atmosphere to simulate the Martian atmosphere.

Although the approach to this program is still not settled, the basic intent is to develop a vehicle that is not just capable of entry into an atmosphere, but one that can measure and calibrate the atmosphere and deceleration rates on the way in. Because the Martian atmosphere is less dense than Earth's it is likely that a completely new entry vehicle would have to be developed, in addition to new instruments to make the desired measurements.

NASA scientists feel that an attempt to use the upper portions of the Earth's atmosphere is a logical and thrifty first step, although it would not represent a complete simulation because scale height and atmospheric constituents are not exactly similar to those of the Martian atmosphere. (Scale heights, however, can be compensated for by the entry angle).

—*Orbital Scanner*—Basically an expansion of OART's already initiated *scanner* project, the new program would provide a small satellite for long-duration testing of new techniques and sensors for horizon scanning. The flights in the original program were all ballistic shots, giving the space agency only a relatively few minutes to gather data.

A small satellite placed in orbit possibly by a *Scout* vehicle would provide the long-term study NASA needs to find out both what the horizon really looks like and which one of the many possible wavelengths and sensing techniques may be the best way to sense it from space.

NASA has said often in recent months that it will explore several means other than traditional infrared measurement techniques in an attempt to improve the current fairly low accuracy methods. Ultraviolet radiation, visible air glow, and radio-frequency measurements have all been mentioned as possibilities in the quest to bring current 1 to 2-degree accuracies down to the order of 0.1 degree.

—*High-Speed RAM* (Re-Entry Attentuation Measurement) program—This is another expansion of a program already set in motion, but an increase that would extend the body of existing data on high-speed re-entry into the regions that should be encountered in manned return from lunar and planetary distances. The RAM flights made thus far have only been to Earth re-entry velocities of 18,000 fps, in the neighborhood of the *Mercury* re-entries.

By using a larger *Scout* vehicle, NASA wants to push the RAM program incrementally to speeds of 35,000 fps, at which the *Apollo* capsule is expected to return, while covering *Gemini* speeds on the order of 28,000 fps enroute to the *Apollo* levels (though not in the same flight). By adding a *Thor-Delta* to the program, scientists speculate they can begin to approach the 70-75,000 fps re-entry speeds that are expected to accompany manned return from planetary distances.

There is considerable concern among space agency scientists as to the feasibilities and techniques required to bring manned spacecraft safely back to Earth from these super-circular velocities (M/R, Oct. 19, p. 41).

● **Shift in emphasis**—In addition to these programs, within the broader ongoing categories of research into which OART divides its effort (propulsion, space power, electronics and control, space vehicles, and human factors),

there are several specific areas which will remain as part of a continuing program but which will undergo significant changes in emphasis in the near future. These include:

● **Propulsion**—In this area, OART is expected to significantly expand its efforts at both ends of the power spectrum. For advanced planetary probes, solar probes, and manned flights to planetary distances, velocity requirements will reach out to possibly 130,000 fps. In combination with these very high ΔV's will be a restraint imposed by the long mission duration.

Together, these requirements will demand more emphasis on studies of new fuels, but particularly a search for those especially suitable for long-term storage aboard space vehicles. Not only will basic fuel research expand but also studies into improved storage techniques, especially long-term storage of cryogenic fuels, which now can only be stored for a relatively few hours. This is true of hydrogen fuel storage aboard the *Saturn*.

Exploitation of the lunar surface as a post-*Apollo* project could also become critically dependent upon the ability to store fuel under the widely varying lunar temperatures that scientists point out range between −200° F and near +200°F. for periods of two weeks at each limit.

● **Low-thrust engine push**—Perhaps the largest expansion in OART propulsion effort is expected in the area of small, very-low-thrust engines, an area one scientist told MISSILES AND ROCKETS has received too little effort in the past. NASA is especially interested in engines capable of thrust levels from very small fractions of a pound each to perhaps a few pounds, primarily for use in attitude-stabilization systems aboard forthcoming long-life satellites. Electrostatic or ion thruster development, in addition to other concepts, is likely to be pursued more vigorously.

● **Space power**—Several traditional stumbling blocks to higher powered, more efficient, on-board supplies will be attacked in this area.

—*Solar cells*—While the major effort of improving these devices continues to go on in industry, NASA is expected to step up its efforts in the area of deployable solar cell arrays that can be packaged in relatively small spaces aboard a spacecraft and then "unfurled" into sheets of active solar cells possibly in excess of 20 ft. dia. Progress in vapor-deposited thin-film cells is the key to this effort.

Development of polycrystalline cadmium-sulfide field-effect-transistors (M/R, Feb. 3, p. 52) and their application to solar cell arrays is also expected to add to lifetime and reduce degradation caused by the space environment. NASA scientists say they eventually hope to push current outputs, roughly equal to 2-3 Btu's per lb. of energy conversion system weight, up to about 10 Btu's.

—*Solar dynamic systems*—NASA officials are expected to request funds in FY'66 for a flight experiment they feel would answer critical questions relating to lifetime and reflectivity characteristics for various large-area solar collectors necessary for some of the proposed solar dynamic or thermionic power systems.

While the space agency is beginning to collect some data on meteoroid strikes, and will collect more later this year when a *Meteoroid Detection Satellite* is slated to be put into Earth orbit by a *Saturn I*, there are many fundamental questions left unanswered concerning the so-called "sandblasting" effect on various materials. This is the continued bombardment of very high reflectivity surfaces by very small particles.

NASA would like to place an experiment in orbit containing samples of various surface materials under consideration to get a better idea of the manner and rate at which they degrade. Once these answers are in hand, the space agency will probably focus on the additional problem of attempting to reconcile the size of these collectors with spacecraft design.

—*Nuclear systems*—In addition to its major on-going work in the *SNAP-8* program—for which NASA has high hopes for the higher-powered (35 kw) requirements of space station and lunar base operation—NASA, and the Atomic Energy Commission in particular, are expected to give added emphasis to lowered-powered radioisotope on-board power systems. Systems are expected to operate to at least 300-500 watts, but new research on improved energy conversion schemes could push this to a 2-kw range.

Also in the nuclear area, another expansion may come in the push to match MHD generators with higher temperature nuclear reactor systems (M/R, Oct. 19, p. 43).

—*Fuel cells*—Future of these systems beyond their use in *Gemini* and *Apollo*, for which development programs are under way, is still in doubt. One possible application is aboard ferry vehicles associated with large manned space stations.

While a major portion of the fuel cell development effort has come from *Gemini* and *Apollo* work at the Manned Spacecraft Center in Houston, OART may step up its research effort into new fuel cell membranes that could give longer life.

Cells other than the ones being developed for the manned space flight program are being looked at and may be accelerated, depending on the operation of the General Electric (*Gemini*) and Pratt & Whitney (*Apollo*) fuel cells. The fact that many of these designs provide a water by-product is a definite plus, and could lead to more integrated life-support and on-board power systems.

—*Batteries*—OART may expand research slightly in an attempt aimed primarily at extending life of secondary nickel-cadmium batteries. Also, basic electrochemistry associated with these devices will get a more intensive examination.

● **Electronics**—In this area, OART will step up its efforts on:

—*Sterilization*—Many questions still remain concerning the effect of high-temperature sterilization on components, and also the more basic question of how much has to be sterilized, the whole spacecraft or just portions of it. Essentially, "we want to make sure that what we study on the Martian surface isn't what we've brought along from Earth," explains one NASA planner. For sterilization, electronic components and instruments will be subjected to temperatures of about 145°C for possibly 24-hr. periods.

—*Optics*—One of the programs viewed by OART as likely to come along eventually is the so-called *Manned Orbital Telescope*. Actually, such a system would not necessarily be manned, but might be visited periodically in rendezvous maneuvers or tethered to a nearby space station.

Whatever the final configuration of such a system, OART has now launched a significant study, via a Marshall Space Flight Center contract to the Perkin-Elmer Corp., which will attempt to define initial satellite experiments. These would give some indication of the utility of erectable space telescopes.

While an *MOT* would have highly demanding pointing accuracies, estimated to be about 0.1 arc sec, the use of lasers for various spaceborne communications and tracking roles being considered (M/R, June 1, p. 30) will demand far more refined pointing (estimated to be on the order of 10^{-5} degrees) and attitude-stabilized systems. Requests for proposals have been issued by OART on studies to attempt to come up with the required stabilization systems.

The *Engineering Technology Satellite* could eventually be tied into the laser experimental developments as the sought-after test bed. In addition, OART electronics engineers also see the *ETS* as a platform for checking out long-duration drift rates on new gyros, new data-compression schemes, and adaptive stabilization techniques.

—*Pneumatic computers*—The effort to develop computers that operate using an air flow rather than electronic signals (M/R, Nov. 23, 1963, p. 51) is



How Cat power helps NASA pick up a 2.5-watt signal from 60,000 miles out

NASA's newest Satellite Tracking and Data Acquisition Network station in Rosman, North Carolina, will help capture the increasing amount of vital scientific data being transmitted to earth daily.

With the new 85-ft. parabolic antenna at Rosman, and the two already in operation in Fairbanks, Alaska, NASA can pick up a 2.5-watt signal from outer space.

Operational this fall, the remote Rosman facility, built and operated by Goddard Space Flight Center, needs great quantities of stable and reliable electrical power. The 85-ft. dish alone, for example, uses a 75 HP electric motor for the upper axis and a 150 HP motor for the lower axis.

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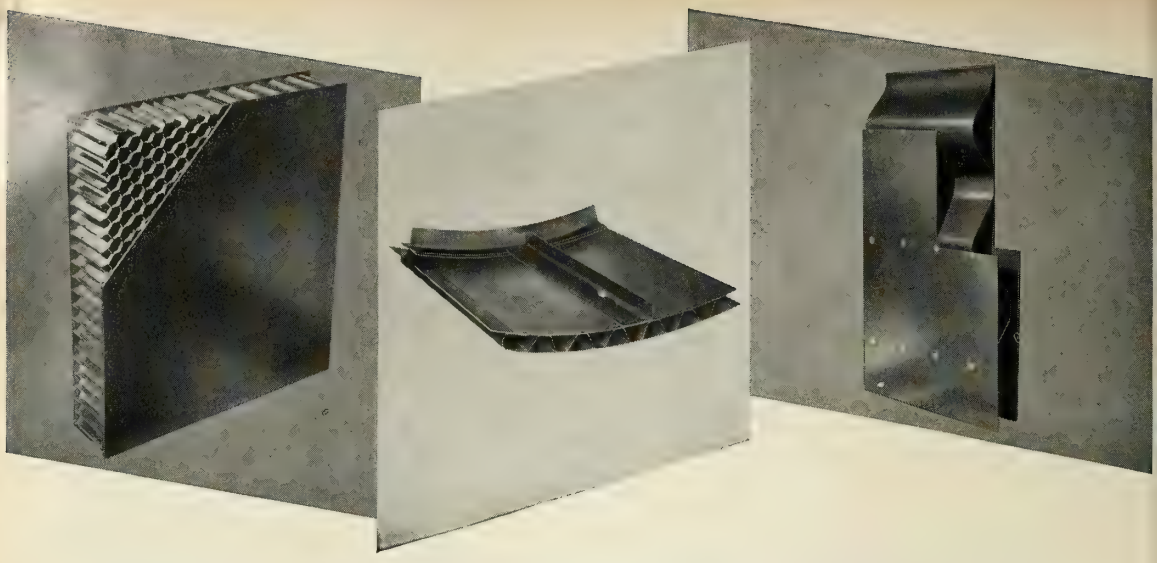
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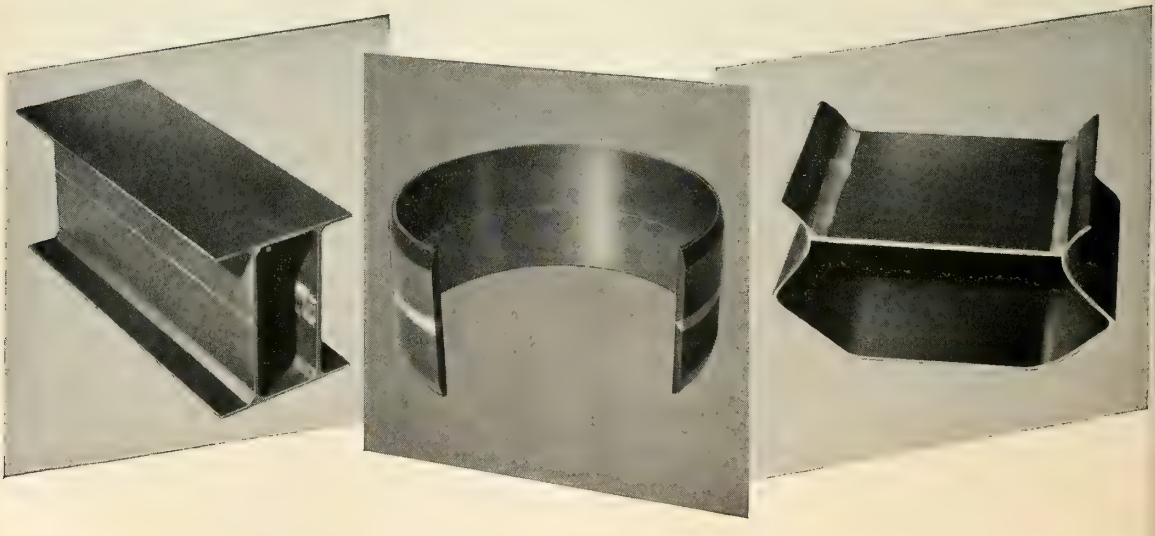
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now at the stage where OART will study the "aerodynamic problems" associated with cornering and channeling the flow in an attempt to build up the speeds of these systems to a point where they may be competitive for some missions.

—*Advanced microcircuitry*—Most of this work will be carried on at the Electronics Research Center. Included in some of the new probings will be emphasis on what can be done with the so-called "amorphous components," which include such things as fluid transistors. These devices, according to ERC officials, basically involve components that melt under very high temperatures but essentially retain the properties that allow them to carry out their electronic functions. A family of such components could give designers relative immunity to the properties of the space environment that have caused considerable problems to date.

In other areas, ERC is also expected to place additional emphasis on development of new sub-millimeter microwave components (M/R, Sept. 7, p. 38), interplanetary guidance and laser radiation experiments. (For a report on ERC's initial electronic research efforts see M/R, Nov. 16, p. 10.)

● **Life support**—This is another area of increasing importance at OART.

NASA officials state flatly that "nothing has stuck its head up yet as the best approach to long-duration multi-man support." The interest here is also in a system best suited to an entire mission profile. The inputs to this work come from several areas in addition to basic human factors. New display techniques will be studied very carefully with an eye toward very-long-term viewing, as will refinements on the estimates of the effect of various g-loadings upon crew members.

NASA says "real progress is needed" in the development of space suits. Requirements are for more mobility, "more shirt-sleeve-type operation and less like a can." OART is interested in improvement aimed at lunar surface operations, especially man's ability to carry a life-support system without seriously decreasing mobility.

● **Wide scope of activity**—OART's charter is very broad. In essence, the continuing program of research explores the technology required to support virtually all possible future U.S. space missions. As one top advanced planner puts it: "the office is basically oriented toward making the technology available for the space agency, if it choses, to go to those places and do those things which will provide either new scientific knowledge or lead to an ability to exploit new areas and phenomena once those areas can be reached."

Since OART's program is not mission-related in the sense of being tied to approved hardware programs, its ability to move into an area before there has been any firm commitments for funds on a project level is far less sensitive. It also provides a good clue as to where the long-range NASA programs may be heading.

Because the mission possibilities are so varied, and because OART must work so far in advance to "keep the technology bag full," it is necessary for this office, usually in conjunction with other NASA offices such as OSS&A, to make its own mission analysis to determine precisely where the future payoffs might be so that the space agency can effectively channel its research.

Among those areas in which OART is certain to support new effort are:

—"A vastly enlarged capability for OART in Earth orbit," say scientists, "both manned and unmanned. We will do more and more work here because it is about the only place left to go to get the total environment that is now needed—weightlessness, vacuum, and radiation. It is also the best place to start on interplanetary testing, though the environment is not exactly the same."

—*Interplanetary missions,* both manned and unmanned, with particular interest in Mars because of the possibility of extraterrestrial life. Key questions to be studied by OART: how much can be done via unmanned exploration? How much will an Automated Biological Lab provide? What are the optimum man-machine cost relationships when considering a manned Mars orbital spacecraft operating with an unmanned lander capsule as opposed to a full scale manned landing? "If cost were no issue," says one scientist, "the way to do it is to put a man down."

—*Solar exploration*—described as "possibly the most important place to explore (the only on-going fusion program and the very large gravitational fields are of major interest) but one of the hardest to get at." This exploration alone will benefit from many of the already initiated OART efforts in nuclear and ion engine propulsion, attitude stabilization, instrumentation, and heat shield development.

—*Asteroid belt exploration* and study of the red-spot pecularities of Jupiter.

Although these areas of interest are very different in terms of distance and environment, there are large similarities in the type of programs which must be carried on to explore any of these regions. For example, placing large payloads in Earth-orbit or smaller payloads enroute to a planet both require large ΔV booster capability. Life support and on-board power requirements for space stations and manned Mars exploration may not be very different.

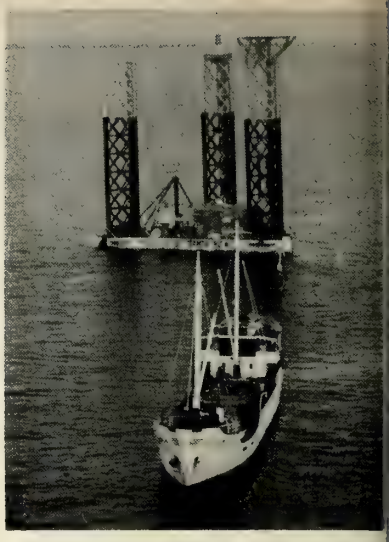
OART's budget for FY '65 is about $0.5 billion. Top planners at OART estimate that this figure will remain relatively stable during the next few years.

A complete report on all OART programs, most of which are being carried forward at their planned pace, was included in MISSILES AND ROCKETS' Third Annual NASA Issue, published Nov. 25, 1963. ■

Space Bearing

A GAS BEARING capable of operating in a vacuum chamber is being used at the NASA Lewis Research Center's Electric Propulsion Laboratory as a research tool. It is used in ground-testing satellite attitude control or station-keeping systems.





LAUNCH platform for Italy's San Marco project on way to off-coast Kenya site.

U.S. Industry To Profit From Progress Abroad

Space agency officials foresee ESRO need for Thor-Delta; Blue Streak may bring others into manned flight 'fraternity'

THE SPACE BUDGETS of foreign nations with which NASA is cooperating will have a combined purchasing power in five years equal to that of the space agency's own Office of Space Sciences and Applications. That figure was $777 million for Fiscal Year 1965.

This is the opinion of officials in NASA's Office of International Programs, headed by Assistant Administrator Arnold W. Frutkin. Frutkin told MISSILES AND ROCKETS this means there will be a much greater potential for meaningful cooperation between NASA and other nations—either NASA participation in another nation's space programs or broadened foreign involvement in NASA efforts.

It also will mean a broadening of foreign markets for U.S. aerospace firms as other nations achieve a level of sophistication in space study that dictates use of hardware that has been pioneered, tested and proved by NASA.

The future need by foreign nations for a larger stable of launch vehicles appears to be one requirement U.S. industry will be able to meet, according to Frutkin. He foresees the need for a medium launch capability (400 to 500-lb. payloads) within the European Space Research Organization (ESRO).

Such a capability would call for a vehicle with a greater lift capacity than that of the *Scout* but not as powerful as the British *Blue Streak*.

Thor-Delta fits this requirement, and Frutkin says there have been preliminary discussions with ESRO of possible purchase of the vehicle. American Telephone & Telegraph Co. brought a *Thor-Delta* to launch its *Telstar*.

● **The near future**—Frutkin listed these other developments as some of the more significant to look for over the next few years:

—Britain's *Blue Streak* will become operational, possibly heralding the inauguration of manned space flight by nations other than the U.S. and the Soviet Union. *Blue Streak's* sophistication and payload capability make it a candidate as the launch vehicle for a manned capsule in the *Mercury* (3,000-lb.) weight class.

—NASA will add West Germany to the growing list of nations with which it is cooperating in satellite programs. The space agency is now negotiating with the German Ministry of Science for development of the first cooperative U.S.-German scientific satellite.

—European nations will be more active in communication satellite programs. These nations, Frutkin says, will not limit their interest to ground stations, but will be eager to cooperate in hardware development and will place contracts with U.S. firms.

—The first equatorial launch site for foreign satellites will be begun and completed.

—Other nations will develop their own launch vehicles, with the leading candidates being Britain (a system based on *Black Knight* technology), France and Japan. NASA scientists will continue to consult with those of foreign nations in bringing about this development.

—Britain, France, Germany, Italy, Japan and Canada (plus the Scandinavian countries, Spain and Switzerland through ESRO) will launch satellites of their own with NASA cooperation.

(Canada has already gained valuable experience, and is sharing vital data on the ionosphere, after launching its still-transmitting *Alouette.)*

—Some two dozen nations will be in the sounding rocket business as the result of cooperation with the space agency, many of them using systems of their own. There will be sounding rocket launch sites around the globe to probe any conceivable environment.

—Finally, experiments contributed by foreign nations may go aloft in Projects *Gemini* and *Apollo*. While no firm proposals for *Gemini* or *Apollo* experiments have yet been received from abroad, Frutkin says preliminary interest has been expressed by individual scientists.

● **Soviets drag feet**—NASA is still greatly interested in implementing the two memoranda of understanding it has executed with the USSR Academy of Sciences, but Frutkin told M/R there is still no "substantive cooperation."

The first memo—approved in August, 1963—outlined procedures to carry out a coordinated weather satellite program, joint experiments with communications using a passive reflector satellite *(Echo II)* and joint contributions of satellite data to the World Magnetic Survey in 1965.

The U.S. mission to the United Nations issued a statement Nov. 6 announcing that a second memorandum of understanding had been approved, covering and refining substantially the same areas for U.S.-USSR cooperation.

The announcement also said that the telecommunications link between Washington and Moscow for transmission of cloud-cover data described in the first memo was being used experimentally. It went on: "Finally, discussions continued (during the recent meetings of the U.N.



NIKE-APACHE sounding rocket is launched from Thumba, India, in joint NASA-INCOSPAR program to determine altitude and intensity of ionosphere electric currents. NASA has aided in nearly 100 sounding rocket shots.

Committee on Peaceful Uses of Outer Space) on the subject of a joint review of space biology and medicine. . . . Consideration may be renewed at a later date."

This leaves implementation of the joint exploration somewhere in limbo. Frutkin feels that scientists in the USSR are receptive to this sort of exchange but have "difficulties in achieving the freedom to discuss even the background for purely scientific programs."

● **Foreign experiments**—Thirteen foreign experiments have been accepted for inclusion in NASA's satellite programs. The first of these, from the United Kingdom's University College, London, was launched Aug. 25 aboard *Explorer XX*, and was designed to measure ion mass composition and temperature with an ion mass spectrometer.

The remainder are:

—A French experiment from the National Scientific Research Center (CNRS) to be launched aboard *Orbiting Geophysical Observatory-C (OGO-C)* next year. It will measure airglow at 6,300 Å, 5,577 Å, 3,914 Å and in the near ultraviolet region with a photometer.

—Two experiments from University College, London, for launch with *Direct Measurement Explorer-A (DME-A)* next year. One will measure ion mass composition and temperature with a spherical ion mass spectrometer; the other will measure electron temperature with a planar electron temperature probe.

—Two experiments, from the University of Leicester and from University College, London, for launch aboard *Orbiting Solar Observatory-D (OSO-D)* in 1966. One will measure distribution of total solar X-ray emission over a wide band; the other will study solar HE II resonance emission at 304 Å.

—An experiment from University College, London, for *OGO-E*, to be launched in 1966 to measure electron temperature and density.

—An experiment from the University of Leicester and University College, London, for *Orbiting Astronomical Observatory-C (OAO-C)* for launch in 1967. The experiment will study X-ray emission of stars and nebulae and obtain information on interstellar absorption of helium.

—An experiment from the University of Leicester and University College, London, for *OSO-E*, to be launched in 1967. The experiment will measure solar flux with a spectroheliograph. A French experiment from CNRS to measure self-reversal of the solar Lyman-Alpha spectrographic line has also been accepted for *OSO-E*.

—Three experiments to be launched aboard *OGO-E*. One from the University of Southampton, England, will measure energetic photons in primary cosmic rays; a second, from the University of Paris, will measure geocoronal hydrogen, and one from Delft Technical Institute, The Netherlands, will measure cosmic ray electrons.

● **Canadian approach ideal**—Officials in the Office of International Programs point to their cooperation with the Canadian Defense Research Board in the International Satellites for Ionospheric Studies (ISIS) series as the most desirable kind of international cooperation in space programs.

The ISIS series follows the trail blazed by the highly successful *Alouette* topside-sounder satellite launched Sept. 29, 1962, by NASA. The space agency provided launch facilities and booster for the satellite, and is still receiving important information on the makeup of the ionosphere.

In such an arrangement, the foreign nation doesn't need a total launch capability—ground support equipment, booster, etc.—but can assume a portion of the costs of certain types of exploration.

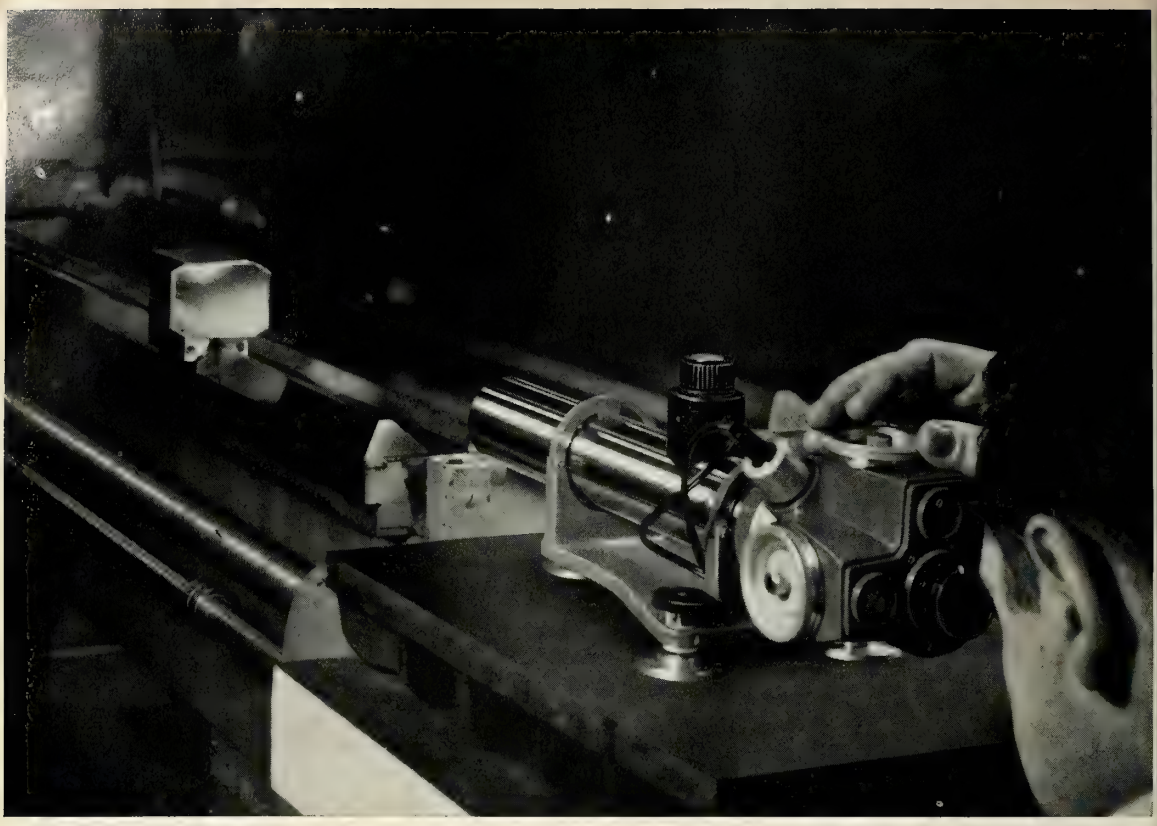
NASA and the Canadian Defense Research Board have agreed to cooperate in launching four more upper-atmosphere research satellites between 1965-70.

Canada will build and pay for the satellites and reimburse NASA for launch facilities and launch vehicles, while both nations will share tracking responsibilities and data gathered by the satellites.

● **Overseas launch sites**—The Office of International Programs takes a guarded approach to use of launch sites proposed by other nations, but has not closed the door to considering them for future cooperative programs.

The space agency is laying the groundwork, particularly in the field of sounding rockets, for a world-wide launch capability in cooperation with such nations as India, Pakistan, Japan and Italy (San Marco project).

Statistics compiled by the Office of International Affairs show that the space agency has cooperated with nearly 70 nations to date in a broad spectrum of space study. Frutkin says there still is a vast untapped potential for more fruitful mutual cooperation as foreign nations, particularly in Europe, continue to expand their industrial capability to include the aerospace field. ■



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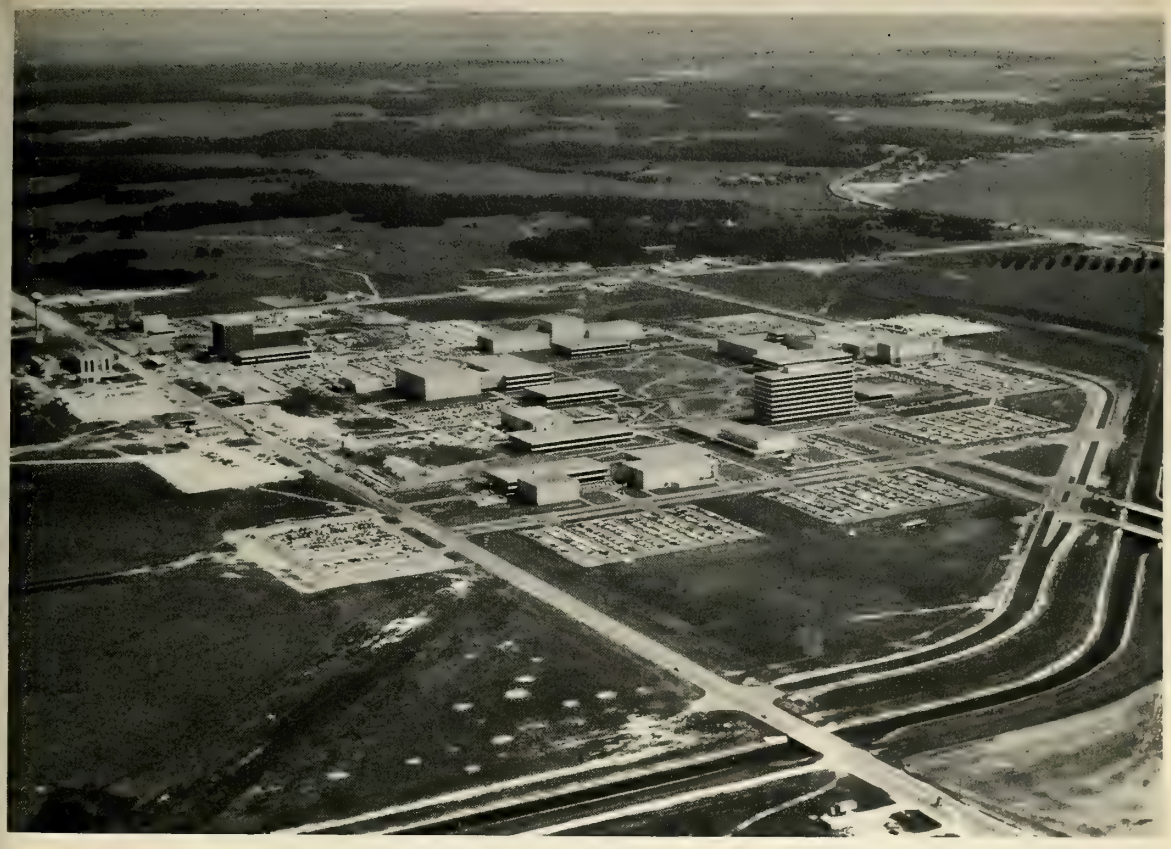
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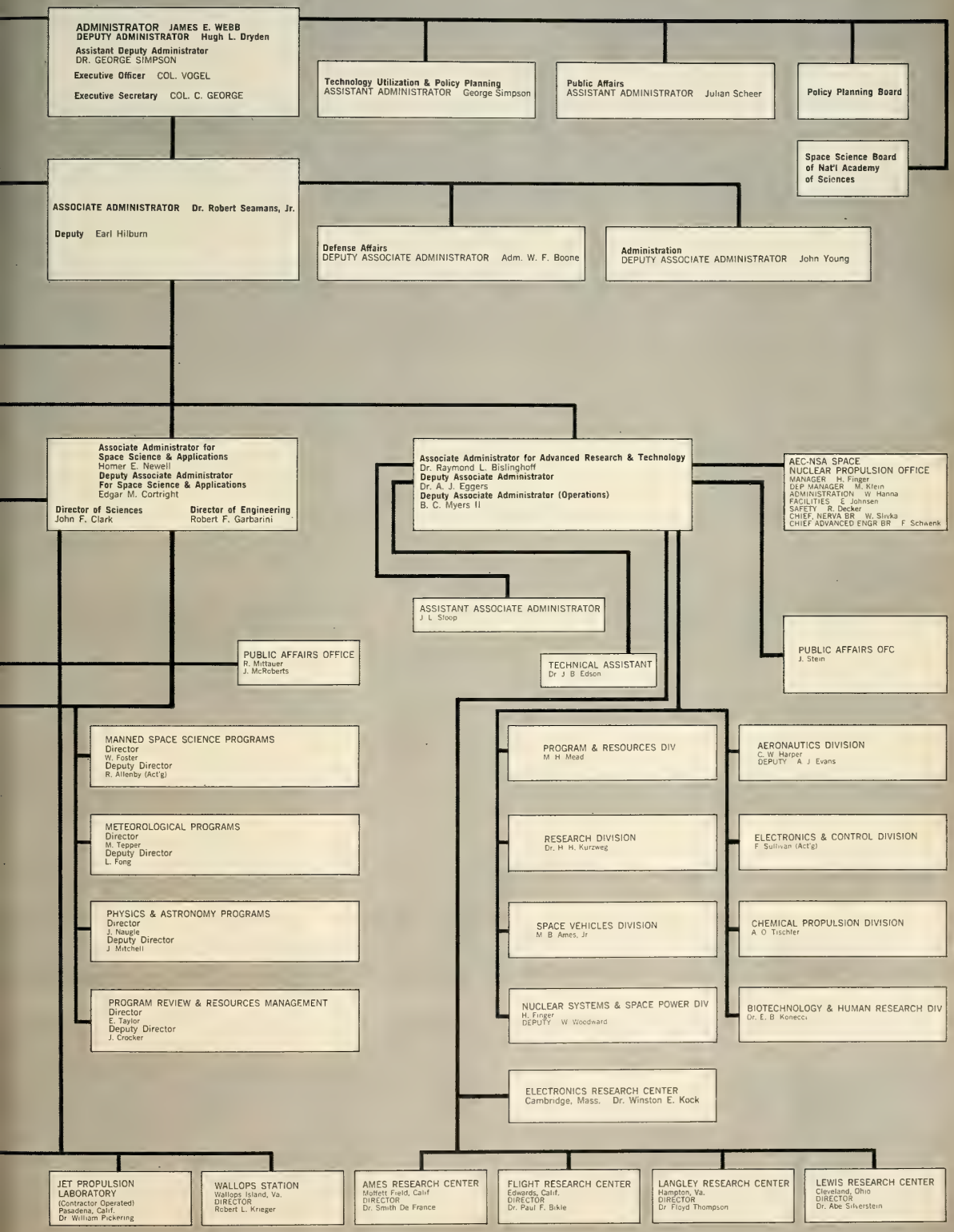
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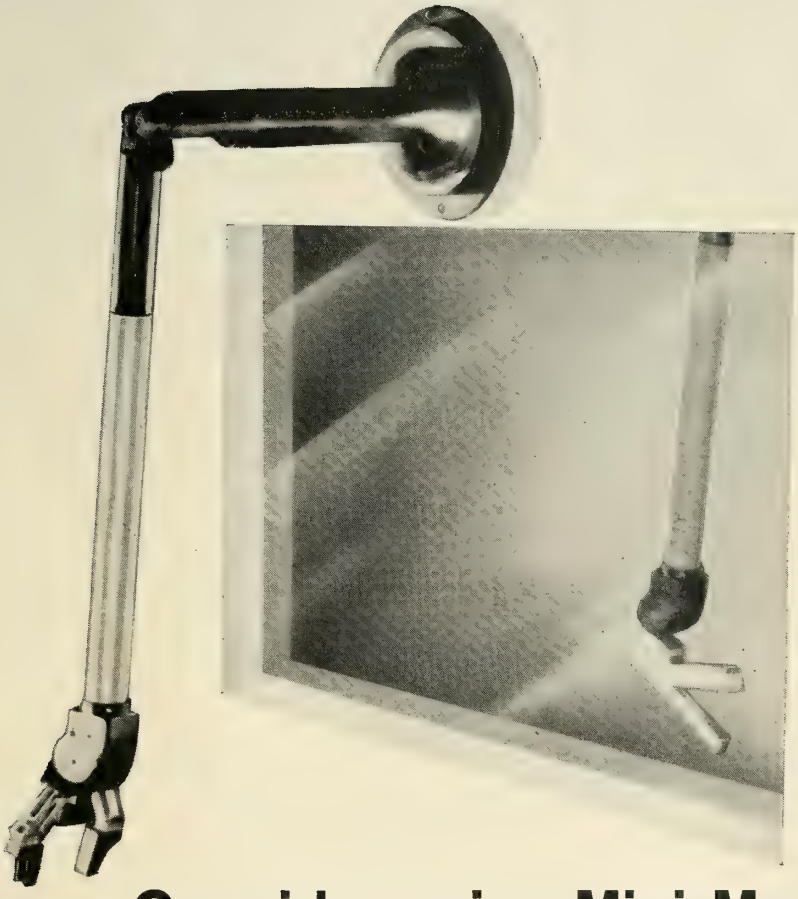
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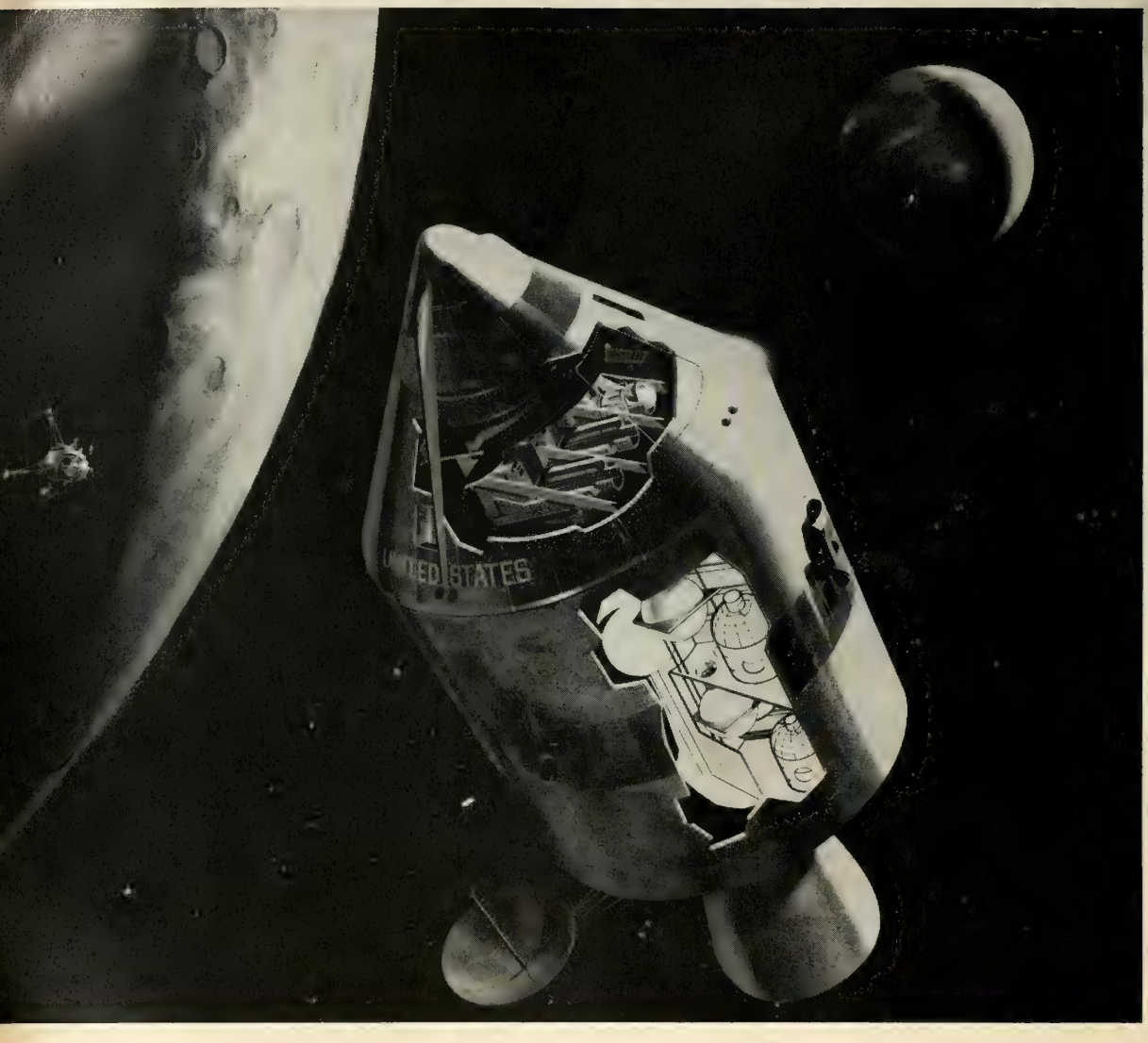
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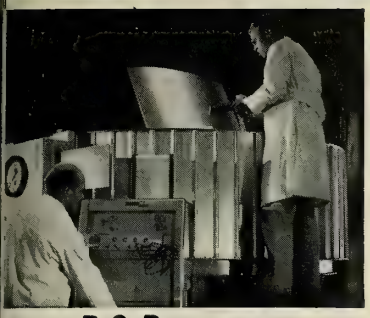
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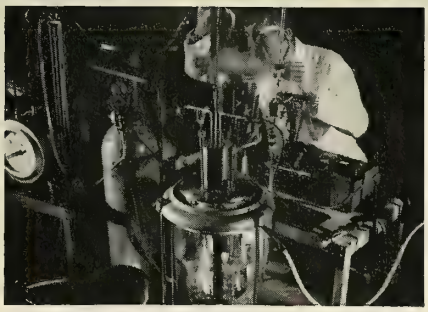
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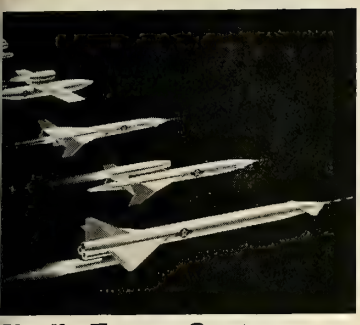
R & D...



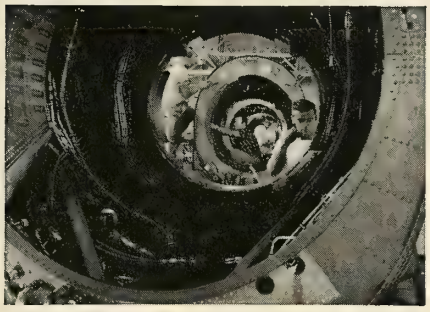
Propulsion...



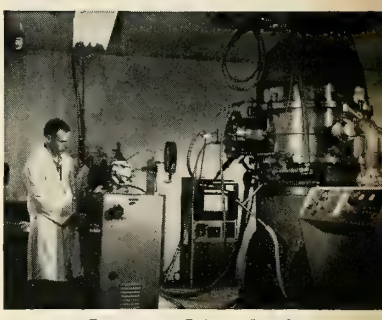
Auxiliary Power...



Missile Target Systems



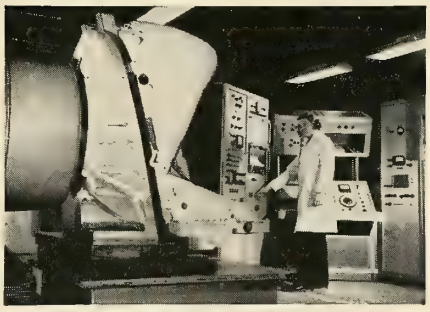
Manufacturing...



Space Simulation...



Facilities...



Complex Vibration...

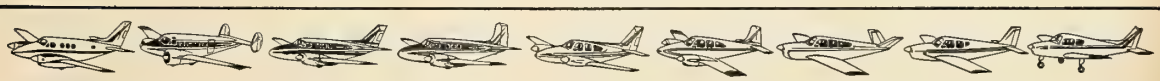


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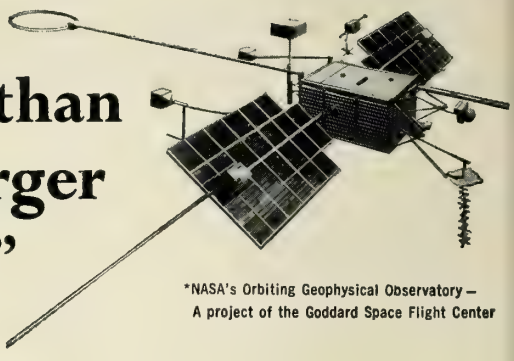


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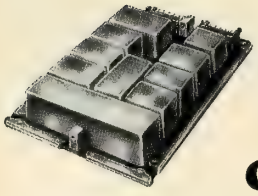
NASA said:

"Develop for 'OGO'* an 8-channel digital data processor consuming no more than 700 mW and no larger than 16 cubic inches."



*NASA's Orbiting Geophysical Observatory – A project of the Goddard Space Flight Center

General Instrument is doing more-



creating a 100% microelectronic package composed of 150 GI Multichip MICROCIRCUITS consuming only 370 mW – all in a space of just 8 cubic inches.

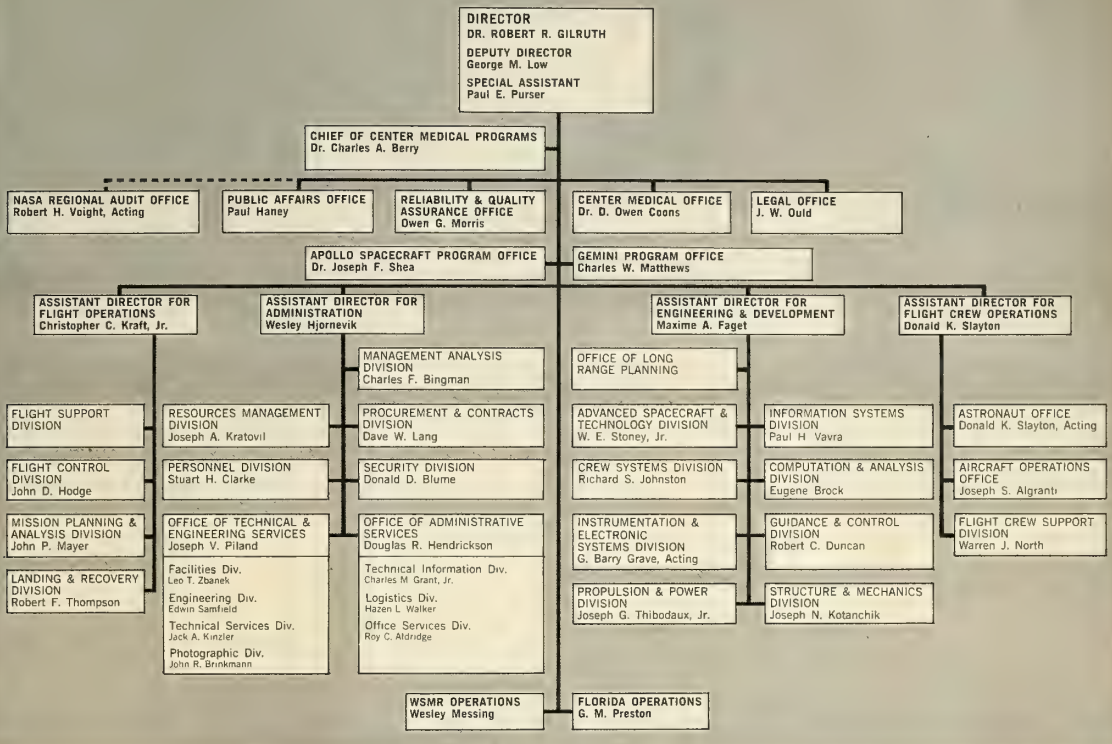
Write for full information on General Instrument's advances in Multichip technology.

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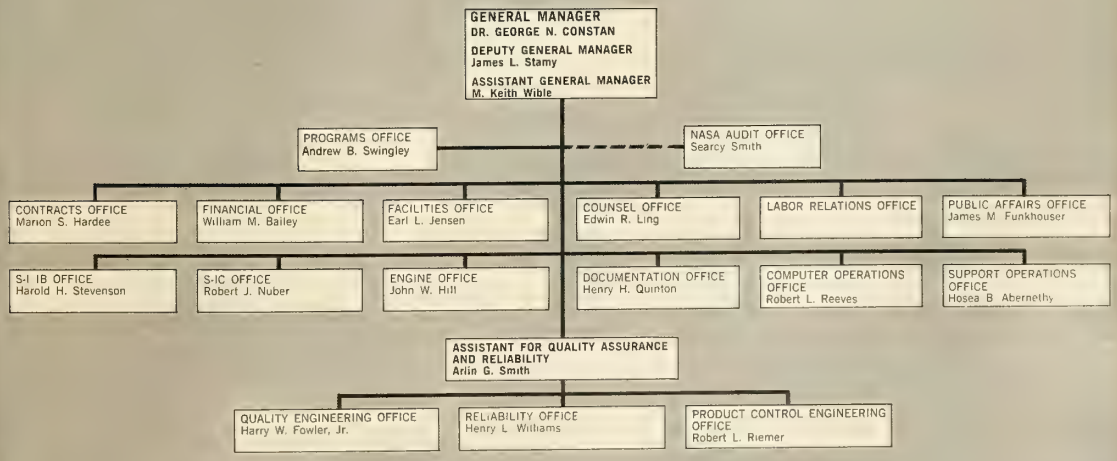
GENERAL INSTRUMENT

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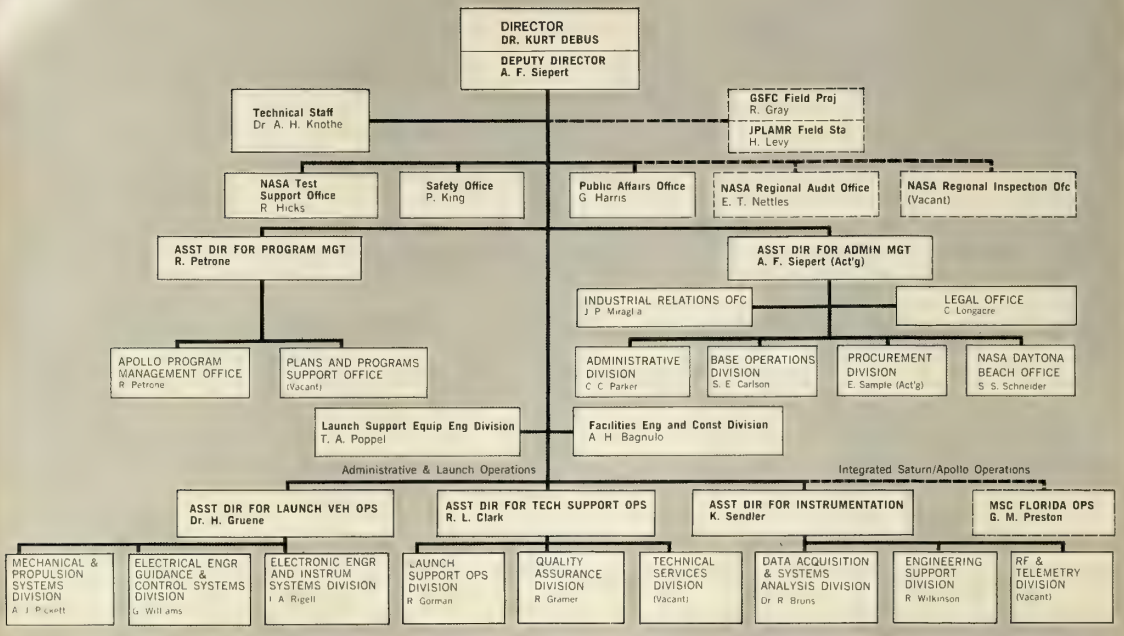
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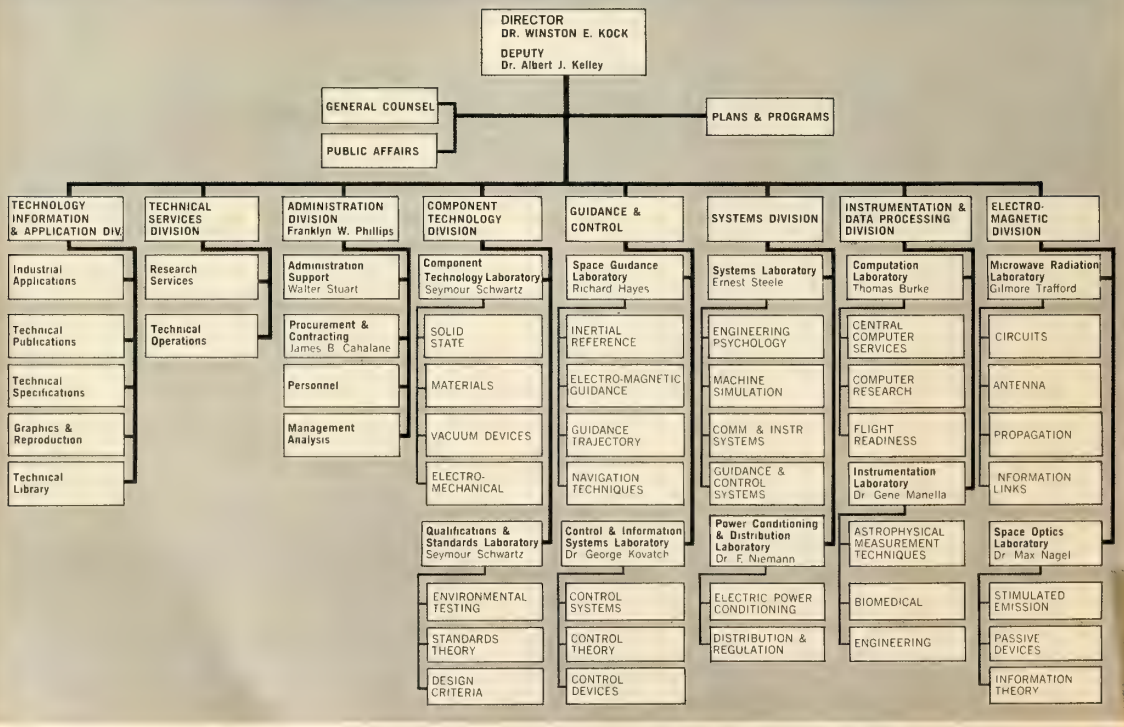
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Advanced lunar missions are becoming more demanding in terms of payload capability and mission flexibility. As a consequence, the sophistication of launch and orbital systems must increase dramatically, which in turn places more and more stringent requirements on the guidance concepts involved.

At Lockheed's Huntsville Research & Engineering Center, working in close support of NASA's Marshall Space Flight Center, the specific areas of analytical research used to increase guidance accuracy and extend its flexibility are based on concepts of calculus of variations. Utilizing these techniques in a manner unique to the aerospace industry, new methods are being developed to determine the steering function which maximizes a desired trajectory characteristic for a given set of constraints. Further, optimal cutoff surfaces are being evolved for a wide variety of proposed missions.

As a result, a recent Lockheed/Huntsville achievement has been the development of a method for finding optimal launch phase trajectories with boundary constraints such as a temperature, load, or vehicle attitude limit.

ENGINEERS & SCIENTISTS: The development of guidance techniques at Lockheed requires an advanced degree and a strong background in mathematics, vehicle dynamics and astrodynamics. A working knowledge of calculus of variations, gradient methods, dynamic programming or Pontryagin's theorems would be helpful.

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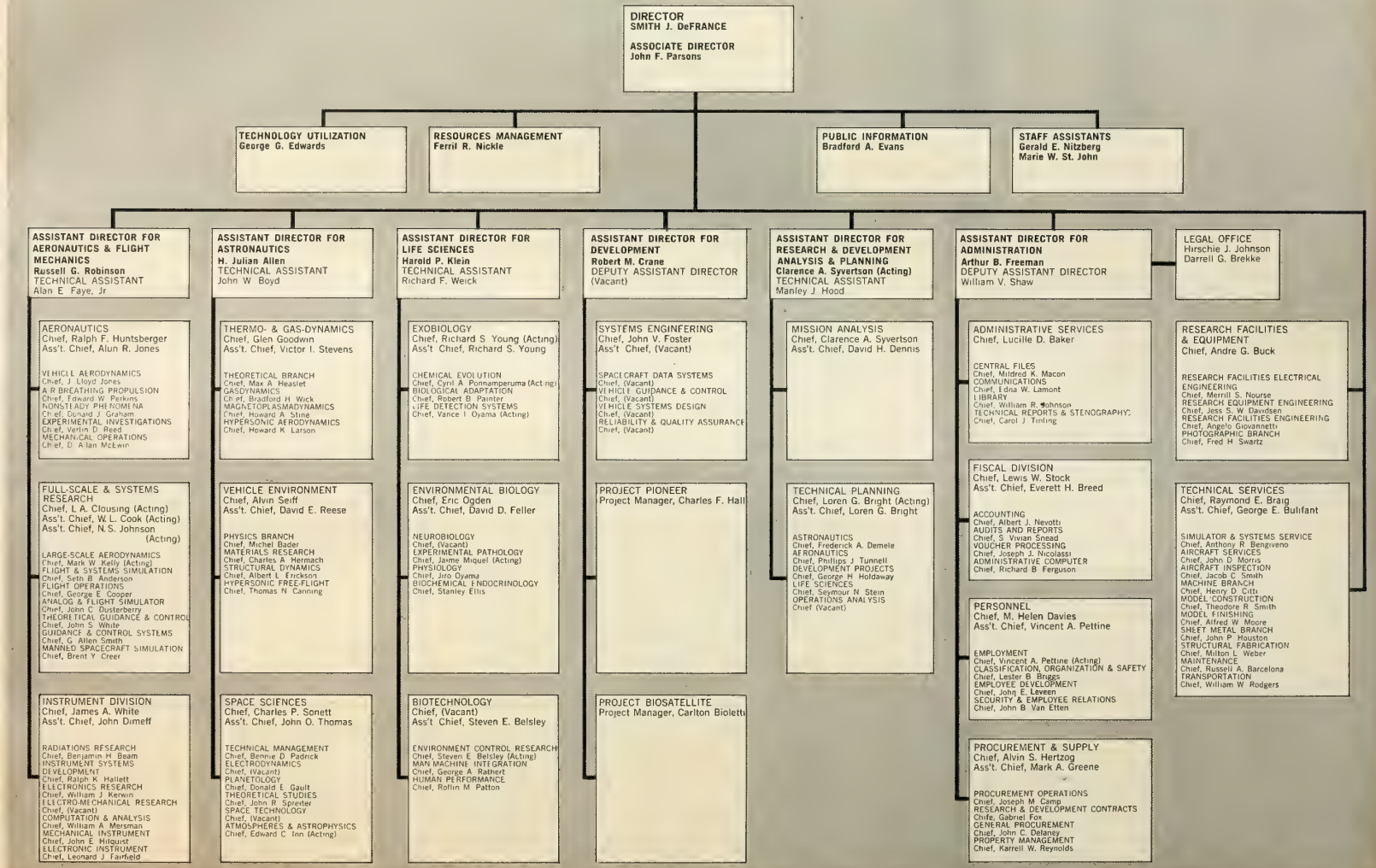
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AMES RESEARCH CENTER



The man who said "you can't take it with you" was born a long time before Garrett started making life support systems.



As a matter of fact, unless man *does* take his earthly environment with him into space, he hasn't got a chance.

For here is a world that has no oxygen, no pressure, no gravity.

To live and work for weeks and months in orbital flight – a need dictated by urgent space projects now in progress – man must have the most sophisticated life support system ever built.

It has to provide him with oxygen, water, pressurization – complete climate control.

It has to guard him against temperatures that range from near absolute zero to the re-entry heat of thousands of degrees.

It has to be a miracle package.

The question becomes: Who is now building such an environmental system?

The answer is, of course, Garrett.

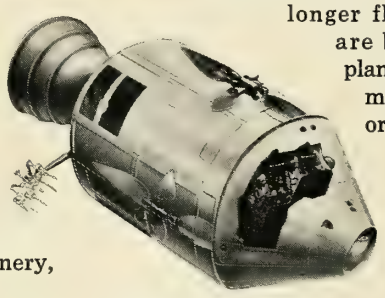
As long ago as 1941, Garrett management saw that man could go no higher, no faster, without pressurization of aircraft. When Garrett's AiResearch division delivered the first systems, suddenly the ceiling was off the world.

Today over 90% of the free world's aircraft carry Garrett environmental systems. Millions of hours of operation have been accumulated by heat transfer equipment, turbomachinery, controls.

This experience led Garrett to build the life support systems that protected our astronauts on the recent Mercury flights.



The same know-how is now at work supplying "shirtsleeve" environments for Gemini and Apollo. These systems will keep man alive for weeks in space. Now longer flights are being planned – manned orbiting



laboratories and space stations. Garrett already knows how to solve life support problems for months in space. Much of the system work is completed and components built.

What are the reasons for this unique capability?

The most experienced men are Garrett men. The most advanced facilities are Garrett. The only applied system for outer space is Garrett built.

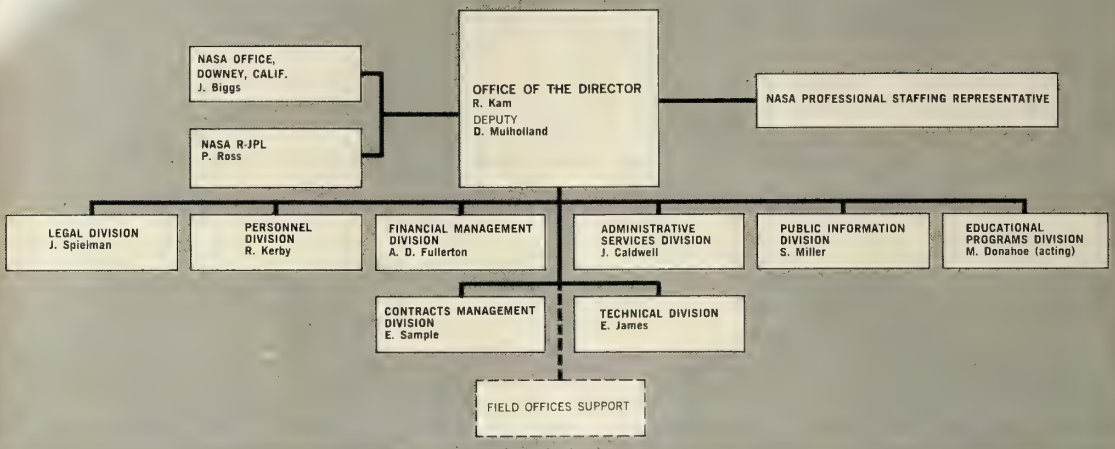
When the problem is environmental, the solution comes from Garrett because...

Garrett *is* experience

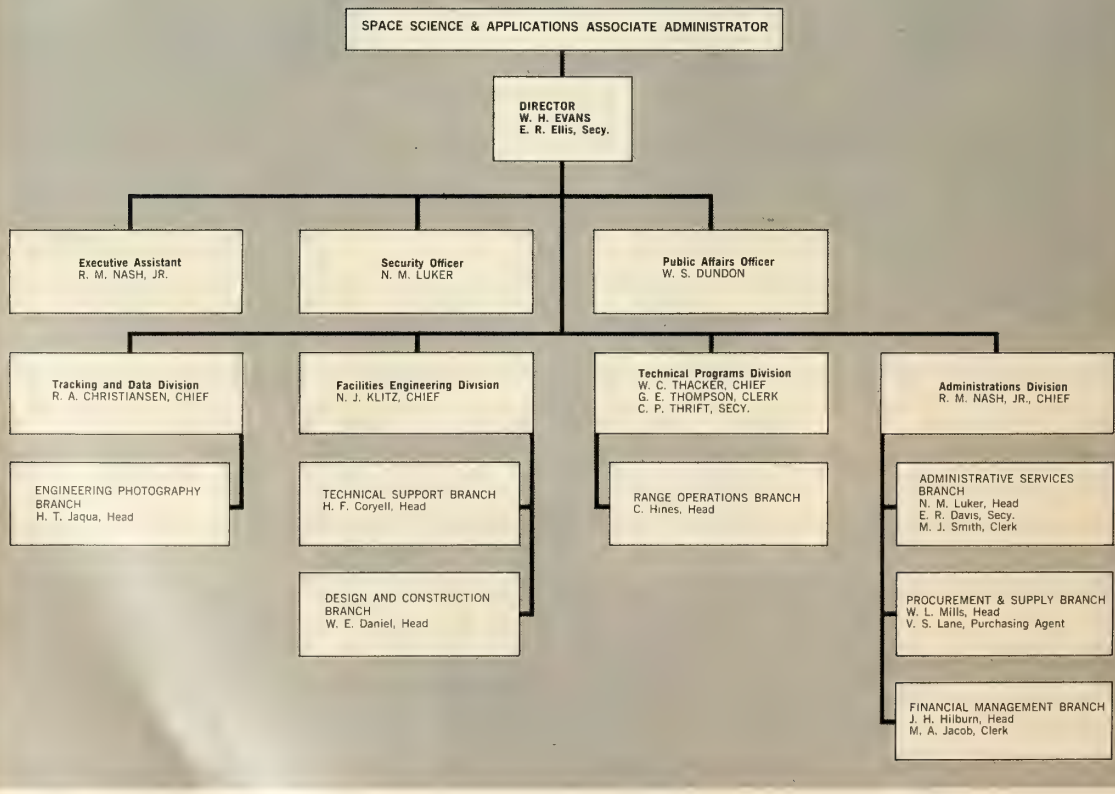
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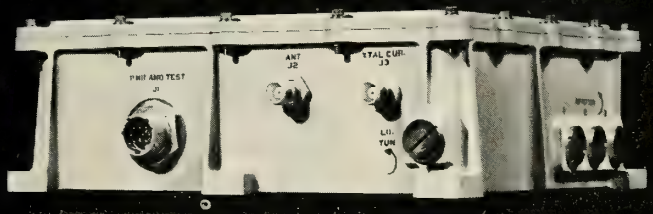


PACIFIC LAUNCH OPERATIONS OFFICE



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RADAR TRANSPONDERS

...e.g., precision C-band model AN/DPN-66 shown above—used on Saturn, Pershing and more than 15 other current aerospace programs. 800 w. nom. peak power, –70 dbm sensitivity, and 50 nanosec. delay stability.

The Motorola family of radar transponders is specified for critical tracking, data and control missions because of flight-proven performance and reliability over the wide range of aerospace missions. Superior delay stability, fast recovery time and demonstrated versatility make Motorola transponders the first choice on projects such as Centaur, Saturn, Pershing, Scout, and at WSMR, AMR, Eglin and Edwards AFB's.

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ON SCOUT, ATHENA and a dozen other aerospace programs—SST-131 microminiature, superheterodyne, C-band unit for high-thrust, solid propellant boosters...–65 dbm sensitivity, 500 w. nom. peak power.

AT AFMTC—AN/DPN-71 provides high-power, superheterodyne, C-band unit for deep space assignments...–75 dbm sensitivity, 20 kw min. peak power.





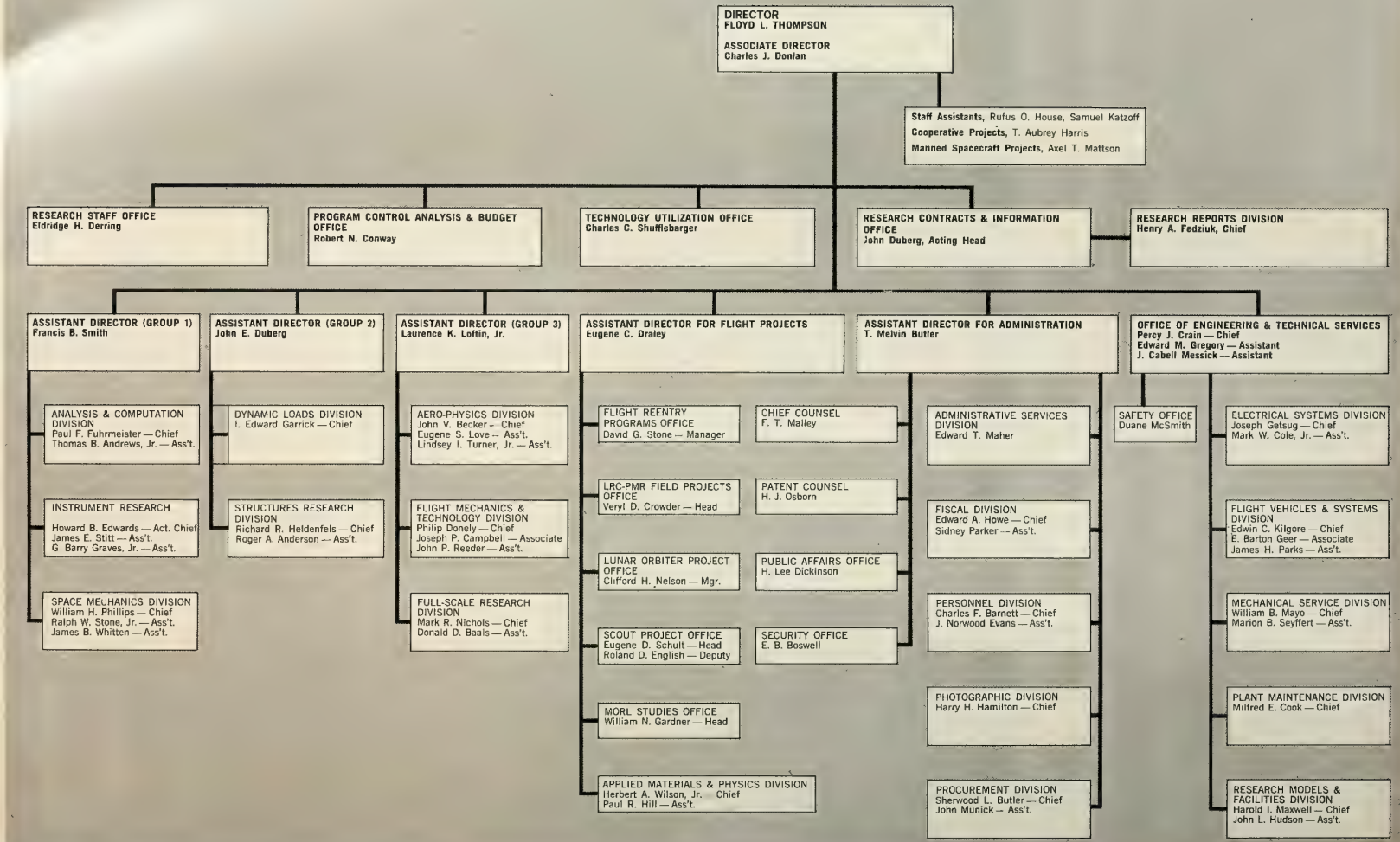
ON DRONES, AIRCRAFT AND HIGH-THRUST BOOSTERS—SST-133X offers most significant advance in X-band transponders in over a decade, is interchangeable at system level with C-band SST-131 model... microminiaturizes widely used AN/APN-132 X-band unit, adds severe environment capabilities.

Motorola is also responsible for major systems and subsystems on Apollo, Gemini, Mariner, Ranger and the Goddard R and RR Satellite Tracking Network.

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OVERWORKED

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ON SATURN, Motorola Model MCR-101 shown in illus. above, provides 10 channels, weighs only 2 lbs., 15 ozs.



ON AGENA—MCR-307, the smallest, lightest 3-channel unit made, weighs but 2 lbs.

ON POLARIS—MCR-312, features an isolated ground system, supplies 3 decoder channels, weighs 3 lbs.





ON MINUTEMAN—MCR-403, contains 4 decoder channels, weighs 3 lbs., 13 ozs.

ON MERCURY—MCR-102/MAD-101, 20-channel receiver-decoder, worked without a single failure throughout the entire program.



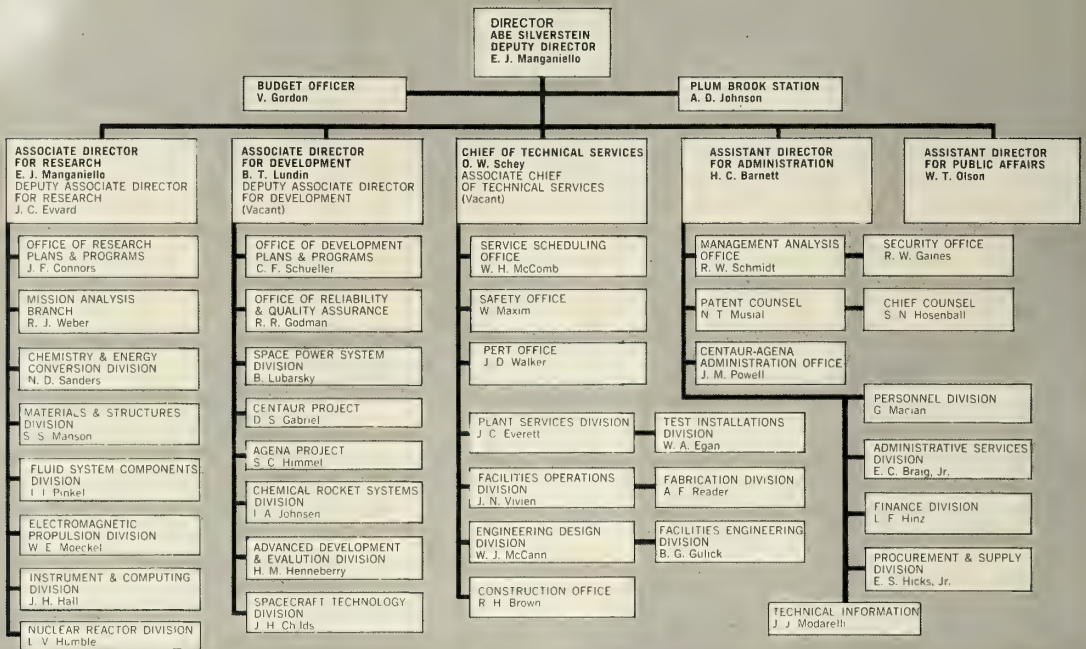
Motorola's Military Electronics Division is also responsible for major electronic subsystems on such programs as Apollo, Gemini, Mariner and Ranger.

Military Electronics Division **MOTOROLA**

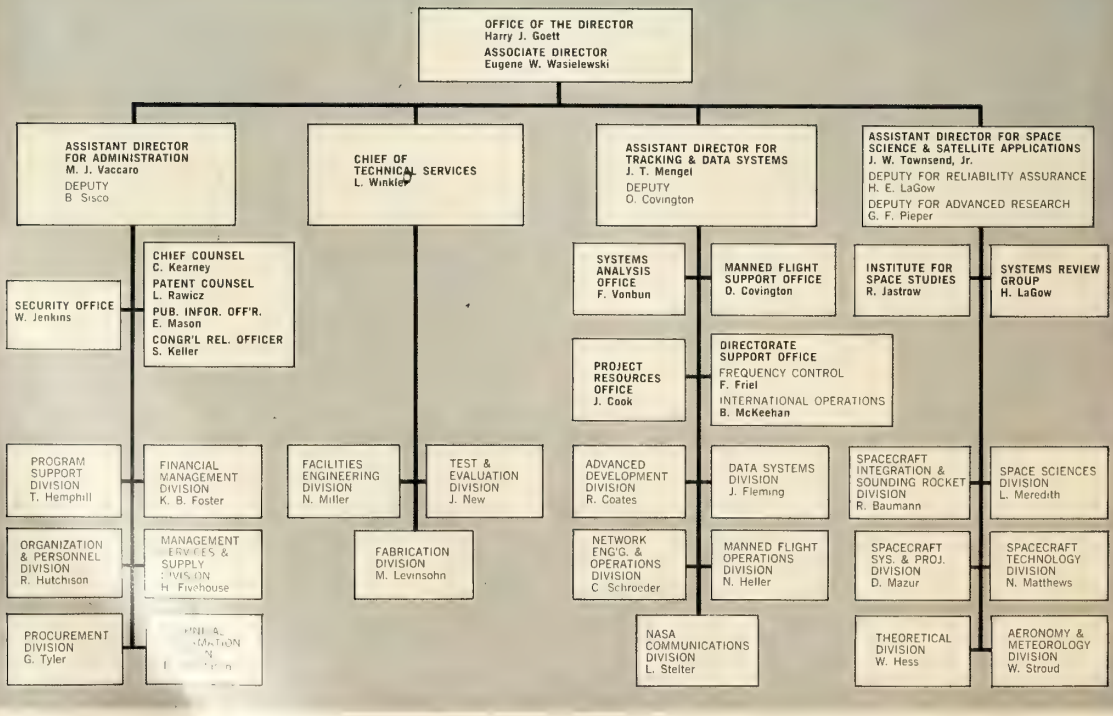
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LEWIS RESEARCH CENTER



GODDARD SPACE FLIGHT CENTER



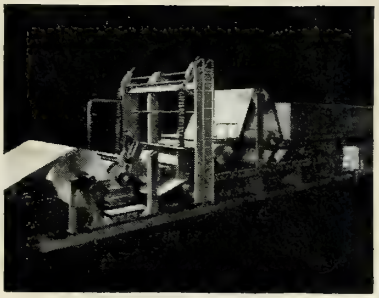
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Engine starters and power generators for tanks and ground support equipment.



Starter generators for gas turbines, and auxiliary power units.



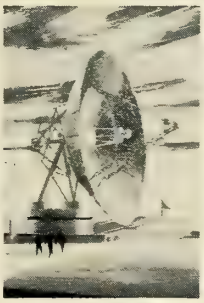
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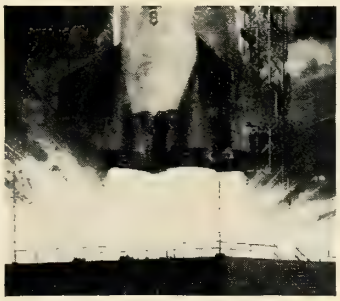
Electrical retarders provide a separate braking system for very heavy vehicles on long downgrades.



Brushless DC motors for torpedo propulsion and space environmental control.



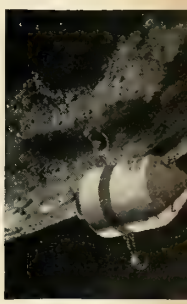
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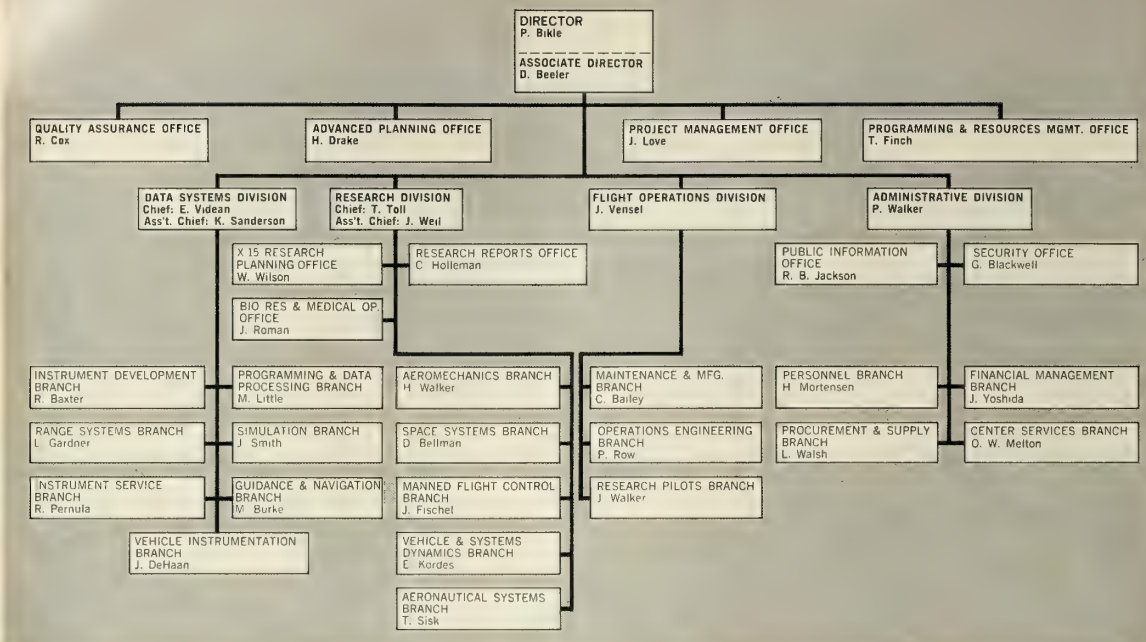
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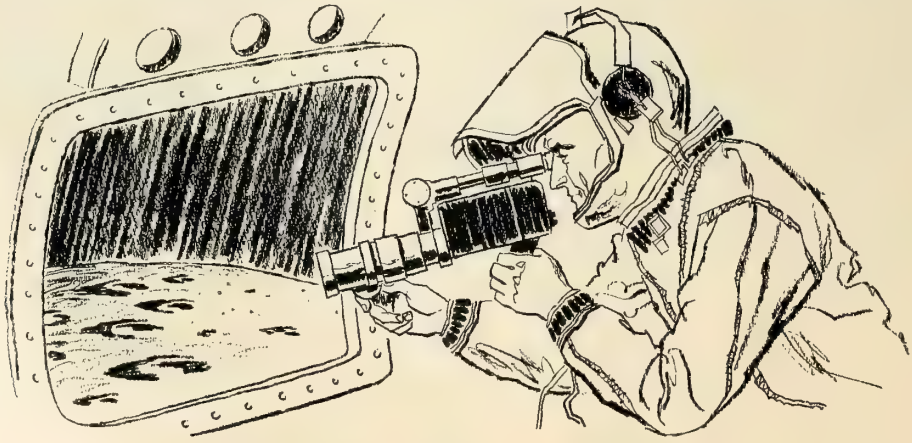
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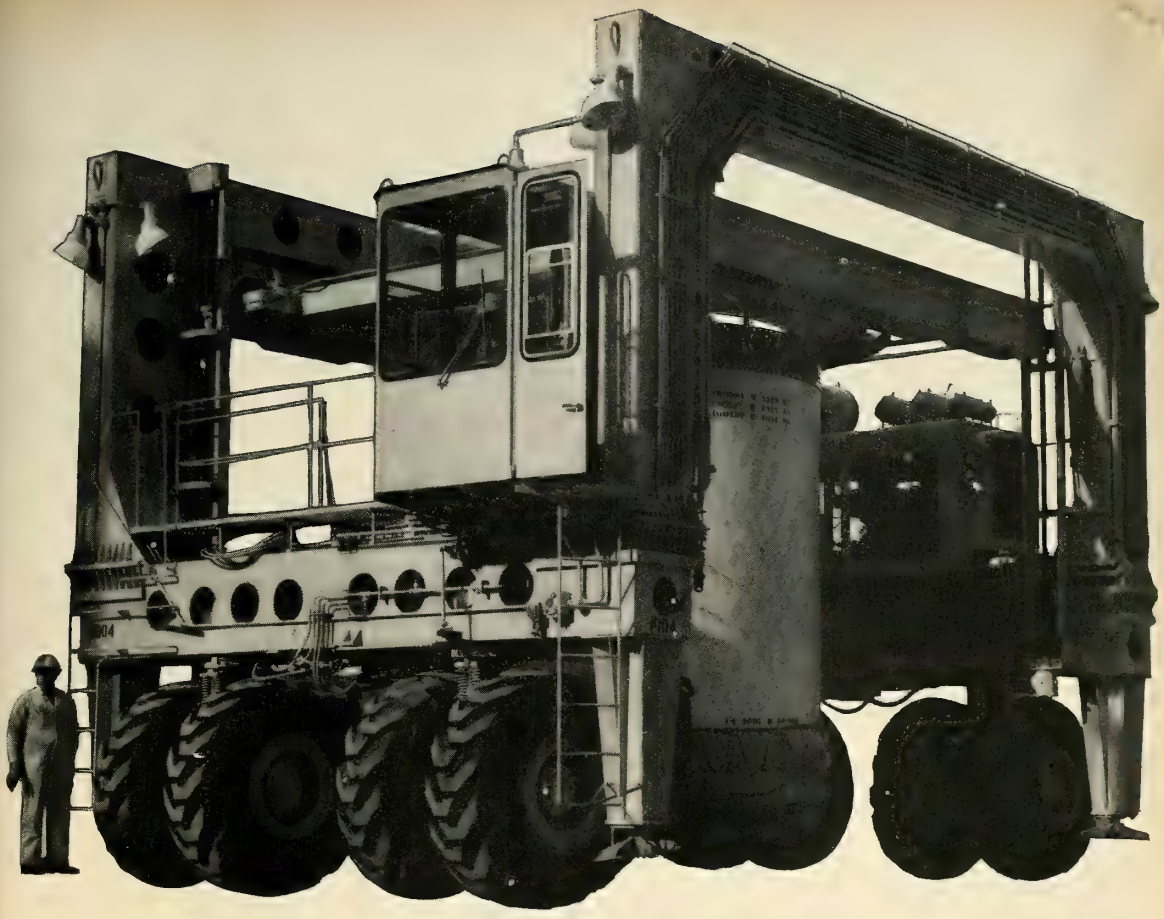
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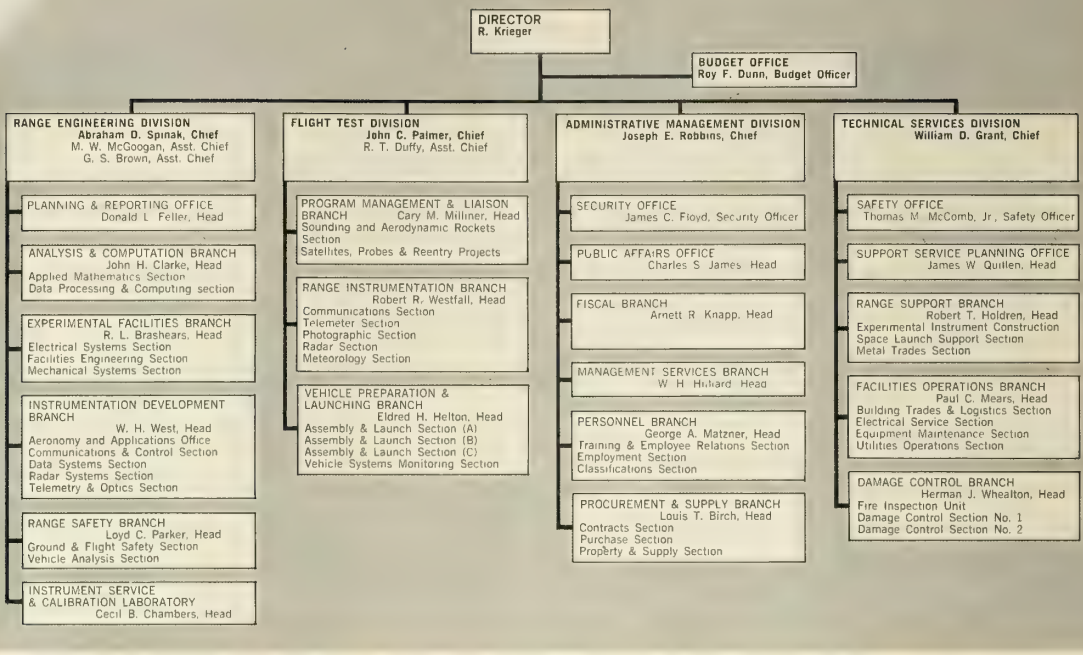
*Developed under subcontract and based on a concept from United Technology Center for U.S. Air Force Titan III-C program.

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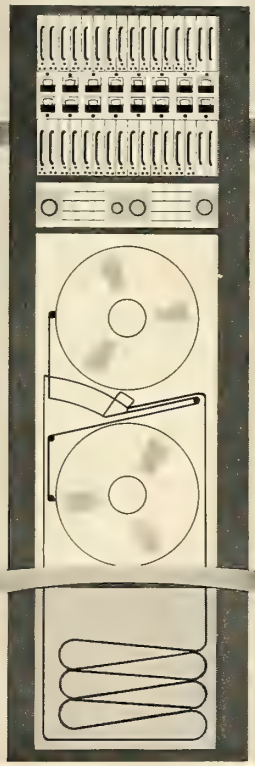
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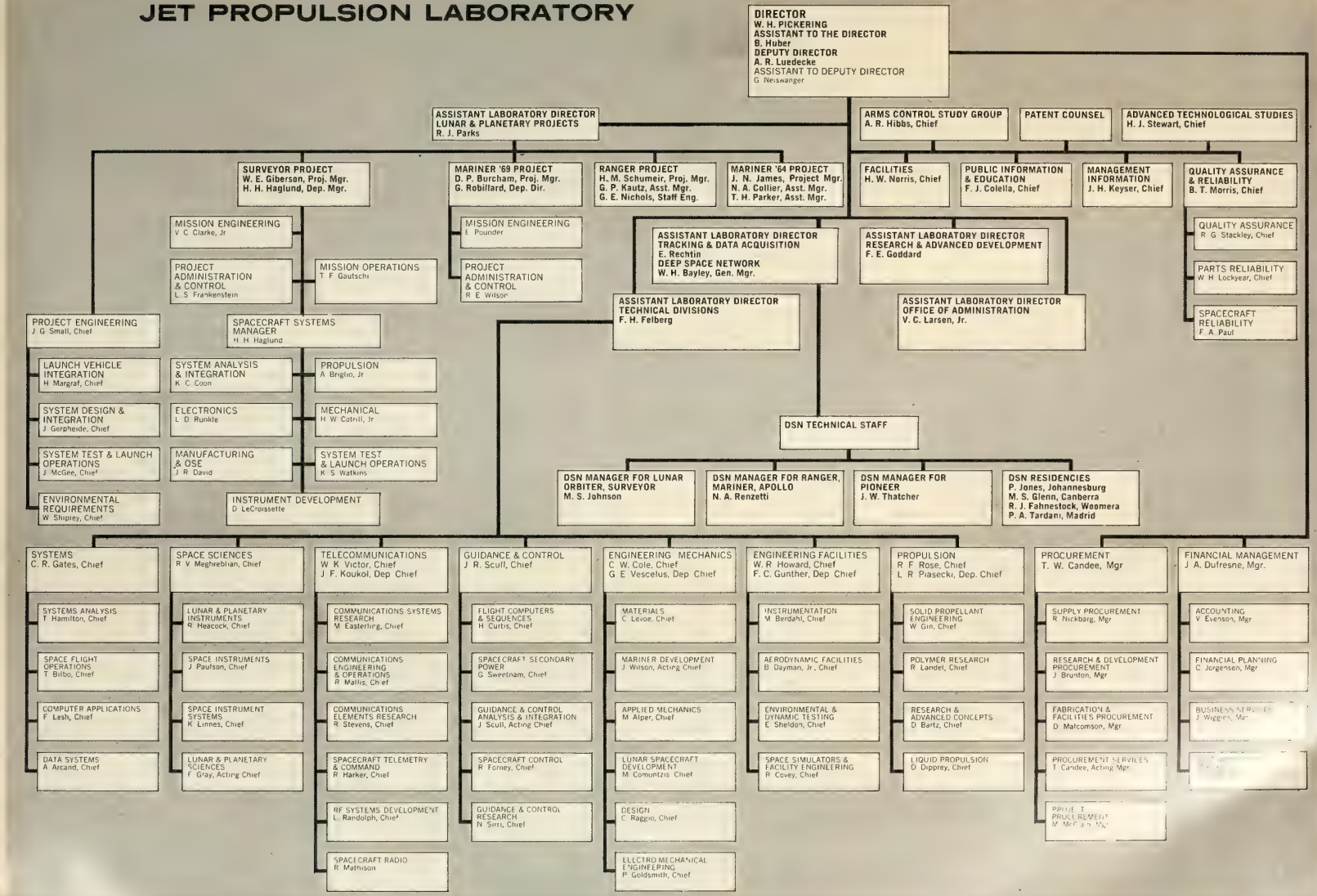
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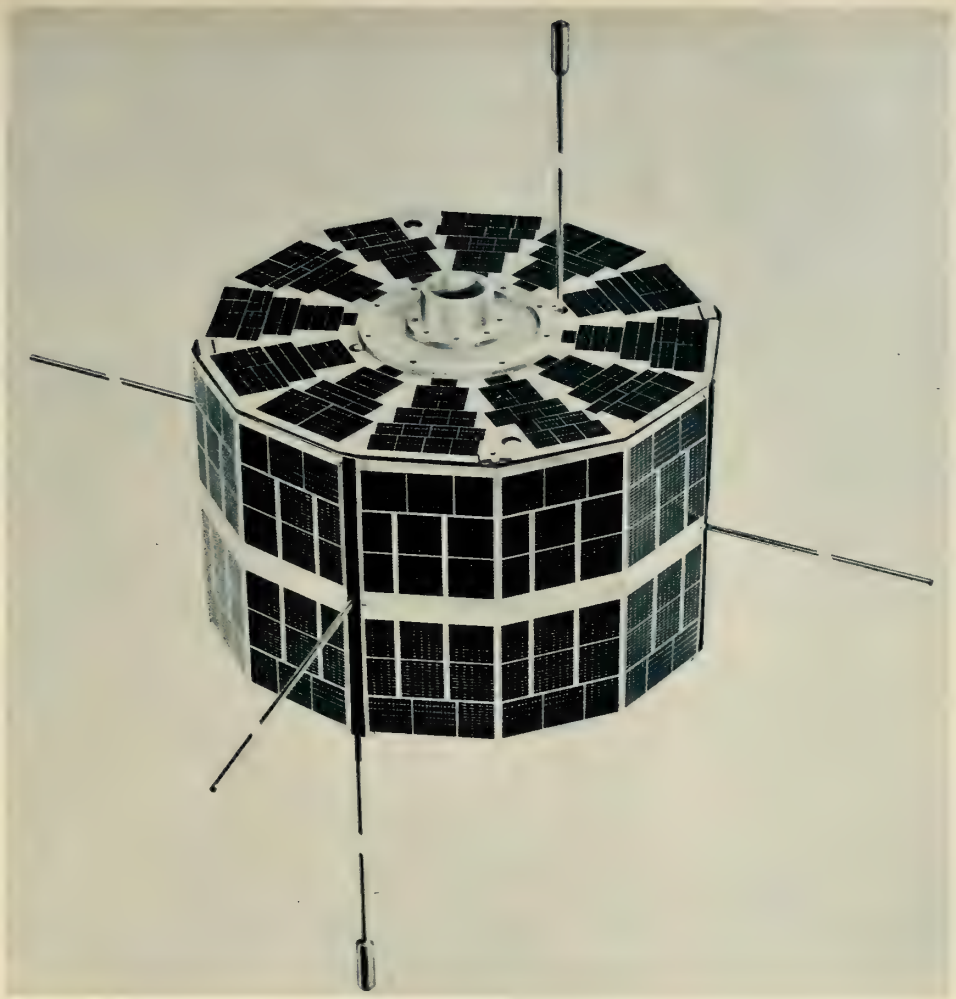
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MODEL OF TRW/ITT commercial communications satellite.

Part III

SPECIAL REPORT: COMMUNICATIONS SATELLITE CORPORATION

Medium- and Synchronous-Altitude Satellite Mix Considered by ComSat

Two key decisions on systems selection due in February and October; upcoming Early Bird tests expected to influence future thinking; FCC ruling on ground station operation due soon

AS THE TIME draws near for a decision on which type of communications satellite system will be put into global operation service by the Communications Satellite Corp., it is becoming apparent that ComSat's original intention of making a clear-cut choice between a medium- or synchronous-altitude approach may be discarded in favor of developing and launching both types in some mixed system format.

The two key decisions on system selection will be made in February and October of next year.

In February, ComSat will have in-hand the results of the three major studies being carried out by an AT&T/RCA team, an STL/ITT team, and the Hughes Aircraft Co. (M/R, June 15, p. 18). These studies will present in detail the proposed designs, capabilities, test procedures, and the highly important fixed-price cost and "guaranteed" lifetime figures for the three possible approaches—the AT&T/RCA random-orbit, medium-altitude system, the STL/ITT controlled-orbit, medium altitude system, and the advanced synchronous altitude system being studied by Hughes.

The February evaluation is not expected to take very long. ComSat and the primary communications companies have worked together closely ever since ComSat was formed in February, 1963, and there are "no surprises" expected. ComSat also now has its computer operating at its new Washington headquarters and the device is expected to quickly provide five-year cost/lifetime projections to be made for each system.

The decision to be made in February, or by March 1, affects primarily the two medium-altitude systems. ComSat will decide at that time whether to launch a development effort on one or both of these approaches. Such an effort would cost $50-60 million dollars if carried through until a first launching in late 1966. In order for ComSat to make this 1966 launch date and the subsequent late 1967 target date for an operational medium-altitude system, if that is the chosen approach, the development effort must be started early in 1965 to insure enough lead time. There is also a possibility that additional funds would go to Hughes to further its development during the February-October interim period.

• **Early Bird**—At about the same time ComSat is deciding on a continuation of the medium-altitude development effort, it is also expected to launch its first *Early Bird* synchronous-altitude satellite. The impact of the first *Early Bird's* performance will be tremendous either if it succeeds beyond current expectations, or if it fails.

Viewed together—the results of all three studies, ComSat's evaluations of them (especially the cost and lifetime numbers), and the performance of *Early Bird* with its built-in 300-millisecond time-delay—will enable the corporation to make a second and more meaningful decision in October as to which system to develop based on about six months operating experience with *Early Bird* and development experience with either or both of the medium-altitude systems.

At that time, if ComSat chooses to give a full-scale go-ahead to either one of the two medium-altitude systems, it will cut off development of the other medium-altitude system. Should it take this path, it is also likely that, if the *Early Bird* system has performed well, ComSat will choose to deploy a synchronous altitude system based on *Early Bird* in the two-year interim in which the medium-altitude system would be under development.

Though the first *Early Bird* is still to be launched, the success of *Syncom II*, which is still operating after a July, 1963, launching, and *Syncom III*, which carried the Olympics TV transmission, the feasibility of these satellites have gained considerable acceptance among ComSat scientists and provides one of the major reasons why the decision is no longer likely to be very clean-cut.

One top ComSat planner told MISSILES AND ROCKETS that, barring unacceptable performance from *Early Bird*, it is not likely that development of synchronous-altitude systems will be dropped completely in favor of medium-altitude systems. "The question now," he adds, "is not whether to use synchronous satellites, but how much of them, when do you factor in medium-altitude systems, and to what extent?"

These factors, in combination with a better understanding of customer requirements which can be satisfied best in certain cases by different satellite systems, also re-enforce the feeling that a mix is the most likely possibility.

• **Policy remains open**—ComSat planners stress the obvious at this point, that until the designs are in and *Early Bird* has flown, the variables are so wide that a policy of flexibility in development options is vital.

The program to place a global system in orbit by 1967 and maintain it thereafter could cost as much as $300 million in the next 5-7 years. It could also be a lot cheaper if *Early Bird* turns out to be a "howling success" and if the alternative medium-altitude cost and lifetime figures were not competitive.

Although this combination is viewed as unlikely within ComSat, they point out that an operational synchronous system could be in orbit "much sooner," and the cancellation of the projected development effort on medium-altitude systems could put the corporation into the black in terms of profitable operation by as early as late 1965. The initial estimates for profitable operation of the corporation are still pegged at the 1968-69 period, though some observers see this as a conservative view (M/R, Sept. 14, p. 18).

● **Budget estimates**—At present, with the major questions still to be settled, ComSat estimates its budget for the next few years as follows:

By the end of 1964, the firm will have spent about $12 million. This will have gone in part toward the *Early Bird* system and the Command and Control Center now being installed for it in the headquarters' building. Also, 1964 funds are being used for the three major studies (AT&T — $1,079,600; RCA—$1,300,000; STL/ITT—$1,265,000; and $100,000 to Hughes for the advanced syncom technology work). The total *Early Bird* cost has been estimated at between $6.3 and $10.8 million.

In 1965, ComSat estimates it will spend $70 million. This will include whatever portion of the $50-60 million medium-altitude development effort is carried through, and probably some additional funding for synchronous-altitude system development.

Initial contracts for at least three, and possibly four, ground stations to be located in the continental U.S. and Hawaii are also expected early in 1965, pending solution of a dispute between ComSat and some of the member carriers and organizations regarding ownership and control of these stations. The stations will cost $5-6 million each, and could cost more dependent upon how many antennas are located at each site, which, in turn, is dependent upon which type of system is chosen. Additional antennas could raise the cost of each site by some $2 million.

In mid-1965, ComSat is also expected to contract for its $10-15 million Master Control Center, which will handle the system that is put into service beyond *Early Bird*. These command centers will have on-site computers and will be tied via teletype to ground stations here and abroad and to Cape Kennedy and NASA's Goddard Space

FCC To Resolve Ground-Stations Fight

ACTION by the Federal Communications Commission is expected before Jan. 1 in an attempt to settle a struggle between the Communications Satellite Corp. and several of the major communications carriers. The issue is control and operation of the initial U.S. ground stations for the global communication system.

The result may be to set a precedent for the situation, in which a privately owned corporation, under substantial government control, must both cooperate and compete with private common carriers.

Both sides argue they are best qualified to meet the requirements for the ground stations set up by the Communications Satellite Act of 1962. Each sees in the other a potential conflict of interest.

Under the Act, the FCC was given power to grant authorization of the satellite terminal stations to ComSat, the common carriers, or both, according to what would "best serve the public interest, convenience and necessity."

● **The squabble**—In August, ComSat asked the FCC for a rule giving it exclusive ownership and control of the initial stations. Five common carriers, a union representing communications employees and an association of independent telephone companies filed statements asking that the request be denied.

American Telephone & Telegraph Co., largest stockholder in the corporation, charged that such limitation of ownership would be illegal under the Communications Satellite Act. Other common carriers stressed they would be better qualified to fulfill requirements for the stations.

In its answering petition, filed last month, ComSat re-emphasized its need for the ownership and control, but suggested that its primary objective—a prompt decision on station ownership—might also be accomplished by a licensing procedure.

ComSat officials stress the need for immediate action so the stations can be operating when the communications system goes into effect in 1966. Leadtime for ground stations is approximately 18 months.

● **ComSat requests bids**—At the same time, ComSat issued RFP's to 15 companies for research data and consultant services for definition of design and performance requirements for the stations. Six firms replied and one or more will be selected to do the work. Those answering were AT&T; ARCS Industries; Daniel, Mann, Johnson & Mendenhall; Hughes Aircraft; Page Communications Engineers; and Westinghouse Electric Co. Winners will be restricted from supplying hardware for the stations.

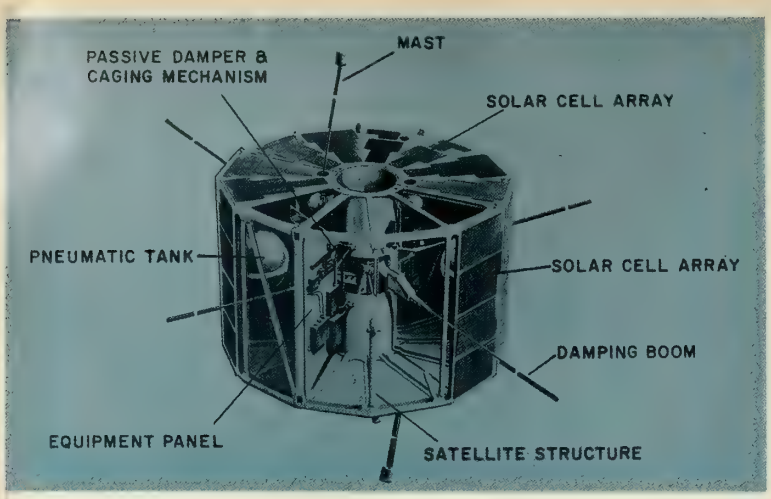
Among the arguments put forth by ComSat is the fact that as owner of the terminal stations, it would have no conflicting interest in competing forms of international communications. A common carrier owning the stations would have less interest in adapting new developments to the satellite system, the corporation maintains.

ComSat also feels that because of the problem of multiple access, the number of U.S. stations should be limited to four. Common carriers competing for ground station business would be likely to exceed this number and thus weaken satellite transmission, ComSat fears.

● **Conflict of interest charged**—The corporation is also charged with a conflict of interest that would freeze technology. A statement presented to the FCC by the Radio Corp. of America says that if ComSat owned and operated the stations, "it would have little economic incentive to advance development of an improved multiple access system. There would be a natural tendency to delay the introduction of a technology that would render obsolete the investments by ComSat and the foreign carriers."

The situation would also reduce the American carriers to a "second-class citizenship," said RCA. Terminal stations in foreign countries will be controlled by authorized communications entities of those countries. "We believe American carriers are entitled to treatment no less favorable," the company told the FCC.

The concept of the satellite corporation's function was to be as a "carrier's carrier," the statement continued. Complete ownership and control of the stations would result in ComSat pre-empting the role of the present carriers in offering communications services directly to the ultimate user, RCA said. ■



CUTAWAY VIEW of proposed TRW/ITT controlled-orbit medium-altitude commercial communications satellite.

Flight Center. The center is planned for limited operation in late 1966 and full capability in late 1967.

In 1966, ComSat spending will rise sharply under the burden of full scale development efforts and early launch costs. Estimates made in September at the first annual shareholder's meeting indicate expenditures during 1966 of about $100 million; however, ComSat president Dr. Joseph V. Charyk told M/R that some of these costs should be more realistically placed in 1967, which would up the 1967 figure above the original $20-30 million level and reduce somewhat the 1966 peak.

ComSat is also expected to develop a continuing R&D program with an annual budget of "a few million dollars," according to planners.

• **Foreign investment**—One of the ironies of the corporation's budget stems from its association with the 13 other nations that signed an interim five-year agreement last August to participate in the global system development. Under the terms set down at that time, ComSat was committed to provide some 61% of the capital, with the other countries providing the remainder (Europe-combined 30.5%, Canada 3.75%, Australia 2.75%, and Japan 2%).

The result of the stock issue yielded $196 million, and another $75-80 million has been paid in by the foreign partners. Since it is very likely that the overwhelming amount of spending for the initial *Early Bird* and follow-on operational system will be spent in the U.S. (though foreign firms will be invited to bid), ComSat, in effect, represents one of the major, and perhaps the only, substantial investment ever made by European governments in work to be performed in the U.S. by U.S. companies. This results in a sort of reverse gold flow, and is not exactly the most beloved part of the interim agreement by the foreign investors.

Though this is good propaganda material, a closer analysis shows that what the foreign investors are really buying in these early years is an in on the technology. In this way, when a permanent agreement is being investigated in 1969 and perhaps the next generation comsat system is being planned, the foreign entities, in effect, will have put together a "deterrent," not so much in the form of an existing foreign-sponsored system, but in that they will have the technology at hand to occupy a very strong position at the negotiations attempting to set up the next agreement.

When that time comes, it will still remain for foreign investors to weigh the manner in which the corporation has operated over its first five years, its profitability, the amount of foreign money already invested in it, and the cost of setting up a competitive system, even though they are then capable of doing so.

• **Foreign motivation**—Foreign nations, however, are expected to share considerably in ComSat research programs and also may be expected to carry off some of the subsystem contracts from the prime contractors designing the chosen systems. ComSat, however, is only under an obligation to get the best equipment at the best price and in the most efficient manner. There are distribution provisions for cases where the bids are roughly equal.

Prior to the award of the three major systems studies, ComSat attempted to pin down four basic items which, in turn, would keep the individual design variables to manageable proportions. These four items included comsat traffic estimates, launch vehicle costs and probability of success, ground station costs, and satellite lifetime.

The traffic estimates used were those settled on at an international communications meeting in Rome last winter. The predicted satellite two-way voice traffic demands, above that which can be handled by other means, indicated a need for 270 circuits in the 1966-68 period, 400 by 1969, 600 by 1970, 800 by 1971, and 1,200 by 1972.

The intent of ComSat, explains Dr. Spencer W. Spaulding, manager for systems analysis, is to make a profit based on this published traffic estimate. Planners are well aware of the "elasticity" of the demand into other areas for comsats once they are proved, however, "we want to make money without this marginal area business, but if it should come the effect might be to provide more service to more people at cheaper rates."

ComSat planners also feel they now have a better handle on launch vehicle success probabilities, improved over the first conservative estimates, and that ground station cost estimates are also better defined. Although the three or four ground stations to be built will probably be similar in design, the reliability and long lifetimes associated with commercial stations such as these is expected to make costs slightly above that which would be normally expected in multiple procurement.

Whichever of the four launch vehicles the corporation chooses (see box, p. 140), the operational satellite system will operate in the 6-gc band for the "up" link and in the 4-gc region for the "down" link, will employ relatively straight-forward wide-band FM systems operating with feedback receivers on the ground, with no on-board multiplexing, and with whatever complexity is not avoidable being built into the ground stations. The operations initially will use frequency division multiplexing. Expanded bandwidth in future satellites will probably allow some of the more complex multiplexing schemes which, in turn, provide increased multiple access capabilities.

HARDWARE AND R&D

Details on the four major satellites in ComSat's future, the ground stations with which they will operate and the program of future R&D to support more advanced systems, follow:

• **Early Bird**—In March, ComSat, using a *Thrust-Augmented Delta* launch vehicle, will attempt to place the first *Early Bird* satellite (sometimes known as HS-303, but which may wind up being called "ComSat-1") into a synchronous orbit, 22,300 miles above the mid-Atlantic.

Early Bird is termed an experimental-operational satellite. The experi-

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mental portion will last about six weeks, and then the satellite will go on the air commercially, hopefully providing 240 channels of two-way voice traffic between North America and Europe.

ComSat has leased the AT&T horn antenna at Andover, Me., for the *Early Bird* experiments. The station will operate with four European stations, at Pleumeur-Bodou, France; Raisting, West Germany; Goonhilly Downs, England; and a small station at Fucino, Italy, which will not be used after the initial six-week experiment. The stations will alternate each week, operating just two at a time. The Canadian station is expected to join the net in late 1965 and details on its participation are now being worked out.

ComSat bought two complete *Early Bird* satellites and parts for a third. It also has an option for 10 more, though this is not likely to be exercised without going to an advanced version. The second satellite could be launched into roughly the same area about six weeks after the first, and could serve as a back-up in the event of failure or as additional channel capacity if the demand expands beyond the single satellite's capabilities. The second satellite could also be used over the Pacific, though a less likely possibility.

The third satellite, according to ComSat, could be ready to launch about five months after the first.

Early Bird is a spin-stabilized satellite, as is *Syncom III*, but it will operate on different frequencies, use a higher powered (6 watts) traveling-wave-tube (*Syncom III* uses a 2-watt twt), and a narrower beam (10 degrees) toroidal antenna radiating a doughnut-shaped pattern which is "squinted" for higher effective power over the North Atlantic route. This will yield about a 4-db improvement over *Syncom III*.

● **Profit potential present**—Although *Early Bird* is tagged with an experimental-operational designation, the satellite's ability to produce income has been generally overlooked in favor of the second-generation operational system to follow.

The fact is that a single *Early Bird* satellite has the capability to produce perhaps as much as $30 million for the corporation's ledger. This figure is arrived at by taking the total number of the channels (240) and multiplying them by the per channel annual rate, which has been estimated as in the neighborhood of $120,000, though this is completely unofficial. In fact, all ComSat rates will be regulated by the FCC, both the rate of profit and the rates charged the customer.

If the $120,000 rate turns out to be roughly correct, it would also illustrate the economies that commercial communications satellites can offer. The annual rental charge on a single circuit between the U.S. and Europe now via cable is believed to be about $240,000, or twice that of the figure being used as an example for ComSat. The current rental rates to common carriers are believed to be less expensive.

AT&T has already indicated it will lease 100 channels on *Early Bird*, and the Canadian government has reportedly expressed an interest in about two dozen more. Additional leasings are expected, probably including some from the U.S. government, including the military. Furthermore, if *Early Bird* is successful and the 300-ms time-delay inherent in two-way voice communications with synchronous-altitude satellites does not prove to be too objectionable, it is possible that the satellite could create its own increased demand over the Atlantic or perhaps to South America and capitalize on income from a second 240-channel satellite.

Echo suppressors, devices that reduce the bounce effect that becomes annoying over very long distances, are being installed in certain U.S. and European phone systems in preparation for the *Early Bird* experiments. Most of the R&D on these devices has gone on in industry, and is continuing because additional improvements are sought.

● **Hughes study**—The $100,000 study awarded to Hughes was not in fact for a completely new advanced synchronous-altitude satellite design, but, as ComSat Engineering Div. Manager Sidney Metzger told M/R, to see

ComSat Ponders Launch Vehicles

COMSAT is now considering four basic launch vehicles for the operational system. They are the *Thrust-Augmented Thor-Agena, Atlas-Agena, Improved Delta* and *Titan II*. These vehicles would have approximately the following lifting capacities for ComSat satellites:

The *TAT-Agena* combination could place two of the STL/ITT satellites into medium-altitude polar orbit on a single launching, or four of the lighter AT&T/RCA satellites. The vehicle is not being considered for syncom use. The *Atlas-Agena* could carry at least four of the STL/ITT variety and seven of the AT&T/RCA types. The *Improved Delta* could loft two AT&T/RCA satellites or one STL/ITT vehicle. The *Titan II* could lift four of the STL/ITT or six of the AT&T/RCA satellites.

The AT&T/RCA satellites are expected to weigh about 125 lbs. each and the STL/ITT approach will result in a 250-lb. satellite.

The advanced syncom, if it were developed, could range in weight between about 120 lbs. and perhaps more than 350 lbs. (one 700-lb. version has been proposed), depending basically on what areas ComSat seeks to improve. For example, by going to a two-transponder operating design, the weight might be held to about 120 lbs. (the EB weighs 90 lbs., exclusive of the apogee kick motor) which could be orbited by an *Improved Delta*.

If more refinements were added, pushing the satellite's weight up to about 350 lbs., then two such satellites could be lifted by a single *Atlas-Agena*. The *Titan II* is not believed to be a major candidate for use with syncoms.

ComSat recently issued requests for proposals to the four contractors whose boosters are under consideration: Martin Co. (*Titan II*); Douglas Aircraft (*Improved Delta* and *TAT*); General Dynamics Corp. (*Atlas*); and Lockheed Aircraft Corp. (*Agena*). By the first of the year, ComSat is expected to evaluate contractors' responses and award studies (possibly multiple) to determine the detailed capabilities or advantages of each booster with either satellite design.

Whatever ComSat chooses, it may have some troubles. For one, launch into a medium-altitude polar orbit will have to take place from the West Coast, but only the *TAT-Agena* has acquired much operational experience from the Western Test Range. The *Improved Delta*, for example, is basically a NASA vehicle to be used from Cape Kennedy and is not now being set up for polar orbital shots from the West Coast.

For another, there are no existing facilities for the *TAT-Agena* at the Eastern Test Range, and while this vehicle is not planned for use with a syncom (which would be launched from ETR), it could possibly be considered as a launch vehicle to place some controlled-type medium-altitude satellites in an equatorial, rather than a polar, orbit to augment coverage.

What this boils down to is, once again, flexibility. "We don't want to get backed into a corner on any one particular booster too early in the program," says one official, who also makes the point that there is some advantage accruing to vehicles that can operate out of both ranges with relative ease, and also perhaps for those with a second-stage offering some maneuvering capability.

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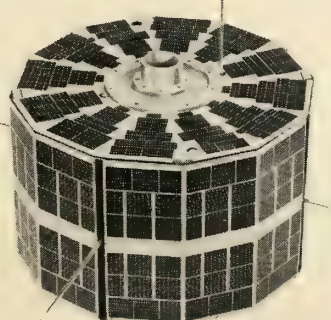
TRW would phase satellites 6000 miles out

***The Communications Satellite Corporation (Comsat)**—Comsat will establish, in cooperation with other countries, a global commercial communications satellite system. It will benefit people everywhere. World-wide intercommunication of business, entertainment, education and culture will give real meaning to "peace through understanding."

THE TRW DESIGN (one of three competing systems under study for the Communications Satellite Corporation)—

Phased—Satellites spaced evenly in each of several "rings," for continuous global coverage and high protection against service interruptions. No control required after initial placement.

Medium altitude—Satellites can operate in polar, inclined or equatorial orbits.



Gravity-gradient stabilization—Completely passive attitude control, utilizing the force of gravity to orient the satellites' antennas toward earth.

Channel capacity—Can handle 1200 two-way telephone conversations or two television broadcasts simultaneously.

Satellite life—Five years average, more than ten years to wearout.

TRW SPACE TECHNOLOGY LABORATORIES
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what could be done in this area by changes in booster capability, and improved electronics.

Specifically, Hughes is looking into what could be done if either the *Improved Delta* or *Atlas-Agena* launch vehicle was substituted for the *Thor-Delta* to be used in the *Early Bird* launch; whether a 75-mc wideband repeater without a limiter that would make the system more amenable to multiple ground station access to the satellite could be developed; and whether a simpler scheme could be developed for electronically de-spinning the satellite's antenna.

Based on the Hughes work to date, sufficient numbers of solar cells could be added to an advanced syncom to permit use of two traveling-wave-tubes, one for each direction of communications travel, with a resultant gain of about 4 db in signal. Though the *Early Bird* also has two twt's, only one actually operates, with both carriers passing through the same one resulting in an equivalent degradation.

The ability to supply more power would in effect give ComSat planners at least two new options for an advanced syncom. By using a higher gain directional antenna, planners here estimate that up to 1,000 voice channels would be possible; or, by going to a wider-beam antenna, the satellite would lose some db and slip back to *Early Bird* channel capacity but would be able to have greater coverage, extending to more than North America.

In its original proposals, Hughes designed a 600-duplex-channel system, that would also be capable of converting to provide two high-quality TV channels. One of the major incentives for development of an advanced syncom in a mixed system might well be its demonstrated capability to broadcast live TV across one-third of the globe.

ComSat scientists also report that Hughes expects to have a completed breadboard model of the simplified electronically de-spun antenna by February.

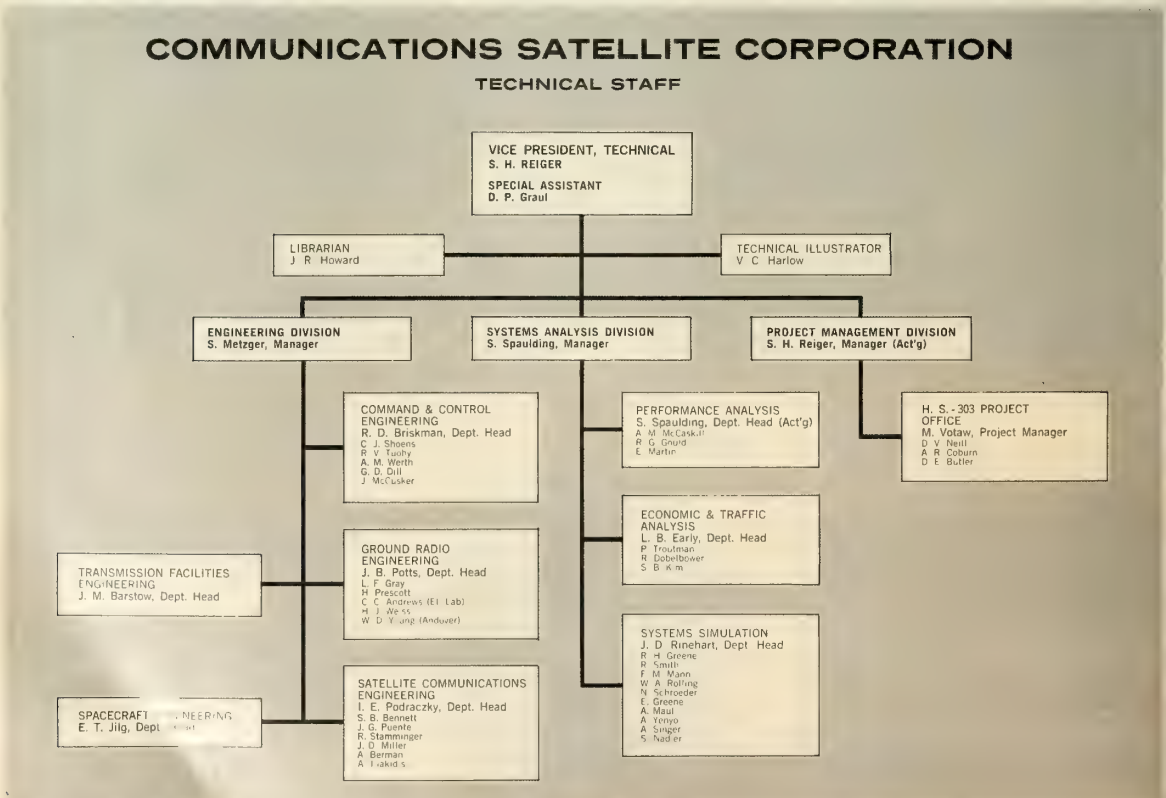
In a somewhat related area, ComSat, under its R&D program, is now negotiating a contract with General Electric for study of a mechanically de-spun antenna.

• **Advanced syncom possible by '66** —Should the corporation signal a go-ahead for an operational advanced syncom system, it could possibly be in operation by late 1966. For a complete global system, six satellites would probably be used, though there would have to be a build-up of communications terminals in the Far East, for example, before it was practical to put satellites over the Pacific or Indian Ocean.

If ComSat decides to fund development of a medium-altitude system and to use a synchronous system as an interim system, then it is expected that it would attempt to feed in as much of the advanced syncom design as is possible. This should be possible, top officials here point out, since the first flight test of the *Improved Delta* is expected by late 1965.

The potential advantages of synchronous-altitude satellites are substantial. The approach requires fewer satellites than the competing medium-altitude system and therefore is likely to be less expensive. The tracking requirements with these satellites are also easier, enabling use of fewer, and less expensive antennas. These two features also combine to reinforce what might come to be a mixed system.

Planners point out that single syncoms, or pairs, could also be used to extend satellite service into new areas which lie beyond the range of coverage of an existing polar-orbiting medium-altitude system—possibly for less than it would cost to add on to a medium-



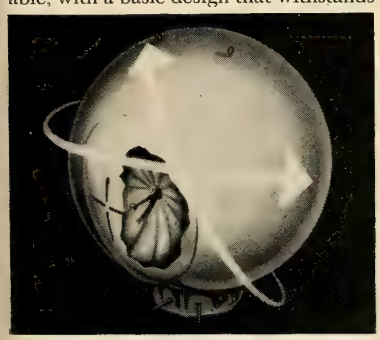
REEVES INSTRUMENT NEWS

Reeves Instrument Company Offers Flexible Full-Capabilities Concept: Today, with both aerospace and defense programs demanding an ever-increasing degree of sensitive instrumentation, Reeves Instrument Company of Garden City, New York, has caught the attention of the industry because of its unique abilities in this field.

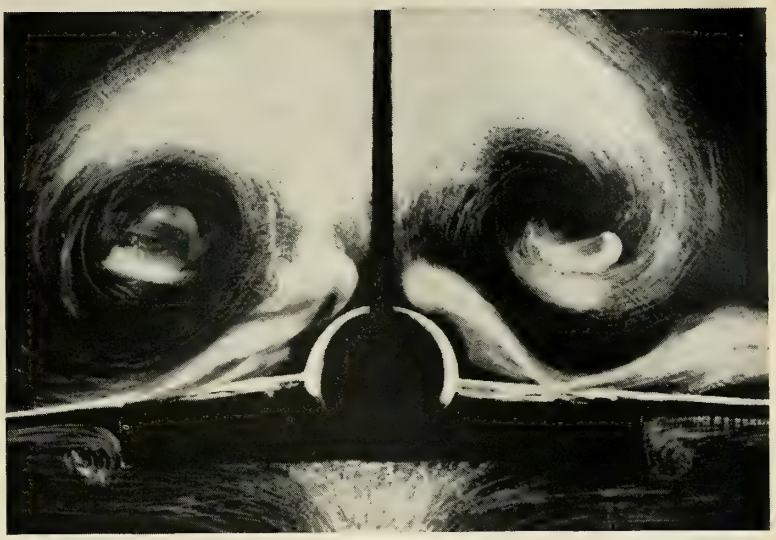
Reeves' integral setup at its Long Island plant operates both horizontally and vertically through a flexible management structure, which puts not only the top corporate thinking of Reeves at its clients' service, but enables every Reeves group and department to borrow both know-how and personnel from the various Reeves departments, and from other divisions of the parent-company, Dynamics Corporation of America, as well.

At Reeves, Research & Development groups, Engineering, Production, Testing and Quality Assurance, and Costing teams at every work stage—all mesh in an effort that provides each client job, large and small, with the greatest possible concentration of scientific-engineering specialists. The over-all results of Reeves' flexible internal structure have been the development of a number of flexible, top-quality, reliable products; the company has evolved a production facility second to none in this deadline-conscious field; and finally, Reeves Instrument Company has been the recipient of many top-flight contracts and projects.

Reeves ROTODOME: New Concept In Antenna Systems Design: Reeves ROTODOME is a precision, two axis antenna system with a spherical enclosure. The ROTODOME's enclosure moves in both azimuth and elevation on its pedestal. This highly-developed Reeves system assures either land or shipboard installations of minimum boresight shift, minimum induced foundation loading, maximum servo bandwidths, and excellent environmental and RFI protection. Especially, Reeves Instrument Company's new enclosed antenna system minimizes wind-induced torques far better than any existing design. Specialists in the field regard the Reeves ROTODOME as a genuine breakthrough in this important area—easy to install, easily adaptable, with a basic design that withstands shock, blast and vibration.



Reeves ROTODOME™: an authentic breakthrough



Supersonic turbulence-flow testing (a typical problem for the REAC 550)

ROTODOME is but one example of Reeves' capabilities in the precision pedestal field, offering designs ranging from two-foot airborne models to massive fifty-ton stabilized shipboard pedestal systems supporting 30-foot reflectors.



12 IG Gyro: Withstands 500 Gs

Reeves Miniature Gyro Unaffected By 500 Gs: One of the most effective products developed by the Reeves Instrument Company's interlocking full-capabilities facilities at Garden City, Long Island, is the 12 IG Gyro—a miniature, integrating gyro which proves out at 500 Gs with no degradation in performance. This makes the 12 IG Gyro unquestionably the ideal choice for today's most advanced inertial reference or stabilization systems. Only 1.25″ in diameter, the 12 IG weighs but six ounces. Standard specifications include 0.1° random drift rate and less than 1°/hr/g acceleration sensitivity.

Reeves REAC® 550 Speeds Aerodynamics, Aerospace Problem-Solving: The flexibility, accuracy and reliability of the new modular Reeves REAC 550 make it especially useful in solving the growing problems that crowd the aerospace and aerodynamics fields today. This is due to the new REAC 550's simplified setup for programming and problem-solving plus its great simultaneous simulation capabilities, and other advantages.

In aerodynamics today, the REAC 550 is involved in many projects and contracts, assisting such diverse disciplines as theoretical physics, systems engineering, applied mathematics. Also, the advanced computer is providing solutions to problems in such vital aerospace areas as missile structures, space environment, structural fabrications and many other present and projected problems.



Typical Reeves Pancake Resolver

Reeves Resolvers Provide Almost Limitless Capability: The small pancake-type resolver shown above is only one among the Reeves Instrument Company's unique, broad-range group of resolvers, synchros, gyros and other components used by many governmental and commercial organizations. Built to custom specifications, Reeves offers a full line of stock models, including 10-second dual and single speed units, multi-speed designs, and tandem arrangements.

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altitude system, and also at less cost to the potential new users who may be able to get in on these operations without heavy investment in multiple tracking antennas.

● **Time delay a headache**—Syncoms, however, are not without their problems, the biggest of which is the time delay. International agreements now state that one-way (that is from the ground station to the satellite and down to another station on Earth) time-delays of 150-ms are acceptable; that those between 150- and 400-ms are provisionally acceptable (this is where *Early Bird* falls); and above 400-ms is unacceptable. Just how troublesome or annoying this feature proves to be is probably the biggest single unknown about these satellites and could rule heavily against their use for voice traffic. It would not affect their ability to handle data traffic or their capability for providing continuous live international TV programming. This approach is far less complicated than the tracking antenna "hand-over" procedures necessary with lower-altitude multiple-satellite systems.

ComSat planners, in addition to evaluating what Hughes proposes in the way of added capabilities, are also still concerned over the lifetime of moving parts, opening and closing in space, associated with syncom positioning equipment (another penalty).

Though all three approaches under study are within the state-of-the-art, the one being pursued by the AT&T/RCA team has the best chance. There are fewest unknowns with this approach, and perhaps that is its strongest argument.

AT&T, with its pioneering *Telstar*, scored heavily for its policy of using only those components and those techniques that are best known and most reliable. *Telstar I* (successfully launched in July, 1962) though still in orbit, is no longer transmitting. *Telstar II*, launched in May, 1963, is also still in orbit and is still transmitting, though it did become silent for a four-week period during the summer of 1963.

Relay I, RCA's first entry into the field, was launched in December, 1962, and, despite a failure of one of two onboard transponders, the back-up system aboard the spacecraft continues to function. *Relay II*, launched in January, 1964, is still operating successfully.

● **AT&T/RCA plan**—The AT&T/RCA proposal calls for a random system of 18 satellites in a circular polar orbit of 6,000 miles altitude. Such a system as proposed would provide about 530 two-way voice circuits, or capabilities for other message traffic or facsimile and two TV channels, one in each direction. Each satellite would contain two active repeaters, each radiating about 4 watts.

AT&T and RCA, in their initial proposal, estimated that based upon their experience with operating medium-altitude satellites, the improvements that could be made in more heavily protected solar cells, and the reliability data accumulated on the twt's to be used (11 of these have reportedly been on life test for seven years) a 10-year satellite lifetime could actually be made a design objective. However, for purposes of ComSat's "guarantee" formula, the firms are proposing a five-year lifetime figure.

The STL/ITT proposal calls for a medium-altitude system with control systems on-board for satellite positioning and spacing in orbit relative to one another. Because of this, fewer satellites will be required, though again, as in a syncom approach, a weight penalty is paid for the control system.

● **STL/ITT approach**—The STL/ITT system would require about 12 satellites in a 6,000-mi. circular orbit. Also included in the satellite design is the use of a gravity-gradient stabilization system that would provide continuous Earth-orientation for each satellite's antenna and thereby provide up to 1,200 voice channels each, with alternatives for other data traffic and TV.

While this system represents perhaps the biggest gamble of all three approaches, corporation planners told M/R that they would not have come this far with this approach if it had not been felt that the technology was feasible. The biggest unanswered question is that of gravity-gradient stabilization. Each satellite would have six 30-ft. booms that would extend in orbit to achieve the proper orientation. "If one doesn't go out, or goes just half way out, you've had it," one scientist told M/R. "On the other hand, if they work, we don't really know what will happen after a year in space."

ComSat, however, is well aware of what the Air Force and NASA have been studying regarding gravity-gradient systems, particularly in effect of the environment on the boom and its shape. The continuation of these programs, and some experiments that should take place before next fall, are expected to play a part in the ComSat decision as to its feasibility. The corporation feels it can have answers in-hand before it becomes necessary to commit substantial funds for development.

In the electronics area, one ComSat scientist points out that STL's highly successful *Nuclear Detection Satellites* have yielded enormous numbers of failure-free component hours. Each satellite has about 20,000 components and two of these satellites have now been operating for more than a year and two others for about three months, all without failure except in the storage batteries used, which have been ruled out for ComSat.

The STL/ITT approach also includes advanced development in the transponder area that could expand the 75-mc bandwidth generally associated with an operational ComSat system to the order of 150 mc. While the other systems use the proven transistor amplifiers, STL is believed to be exploring the use of combining tunnel diodes and low-level twt's in an intermediate power stage in order to broaden the total bandwidth.

● **Ground station questions**—The development of ground stations in the U.S. and Hawaii to handle the operational system is now in an unsettled state, and is likely to remain so until the FCC rules on the contesting petitions between ComSat, on the one hand, and a majority of the member common carriers, the communications employees union, and the association of independent telephone companies, on the other.

(For a detailed discussion of the ground-station controversy, see story on page 137.)

The basic question is whether ComSat will own and operate the ground stations. Though the arguments may be somewhat soft-pedaled in public, the behind-the-scenes battling is expected to be fierce and the eventual outcome is likely to have an effect on many future ComSat dealings. An organization such as ComSat, completely unique in terms of corporate structure and charter, is basically fraught with possible conflicts of interest which, if they can not be controlled and effectively dealt with, could spell trouble at any time.

The key argument made by ComSat in response to the objections is that "it has no conflicting interest in other forms of international communications with which the satellite would compete" (e.g.—it owns no cables or land-line circuits).

ComSat says the ground stations require an 18-month lead time and it would like to get the RFP's out early next year.

The firm has already asked some 15 companies to bid on what in effect will be a research contract effort aimed at drawing up specifications for the major ground station components. Six firms have responded (see box, p. 137). A contractor was expected to be selected by November; however, until some sort of settlement is worked out on the station ownership, the ground station effort will go no further into hardware procurement. Corporation officials say



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Multi-unit array of Ling's Model 310 Thruster provides unlimited force capability.

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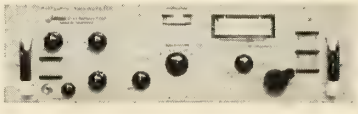


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these studies will also be helpful to the carriers should they win the battle for control.

● **Diverse terminal types**—Actually, the design of satellite ground terminals has followed no real pattern among those already built. As Metzger points out, there are five major stations and four different designs; The Bell System antenna at Andover is a horn type, the one in France is a copy of it, the Germans have designed a Cassegrainian system using a horn feed, the British use a parabola with a front feed, and the Canadians will use a Cassegrainian with a monopulse feed.

Under the ComSat concept, there will be either three or four new ground stations built for U.S. participation, basically depending upon which satellite system is chosen.

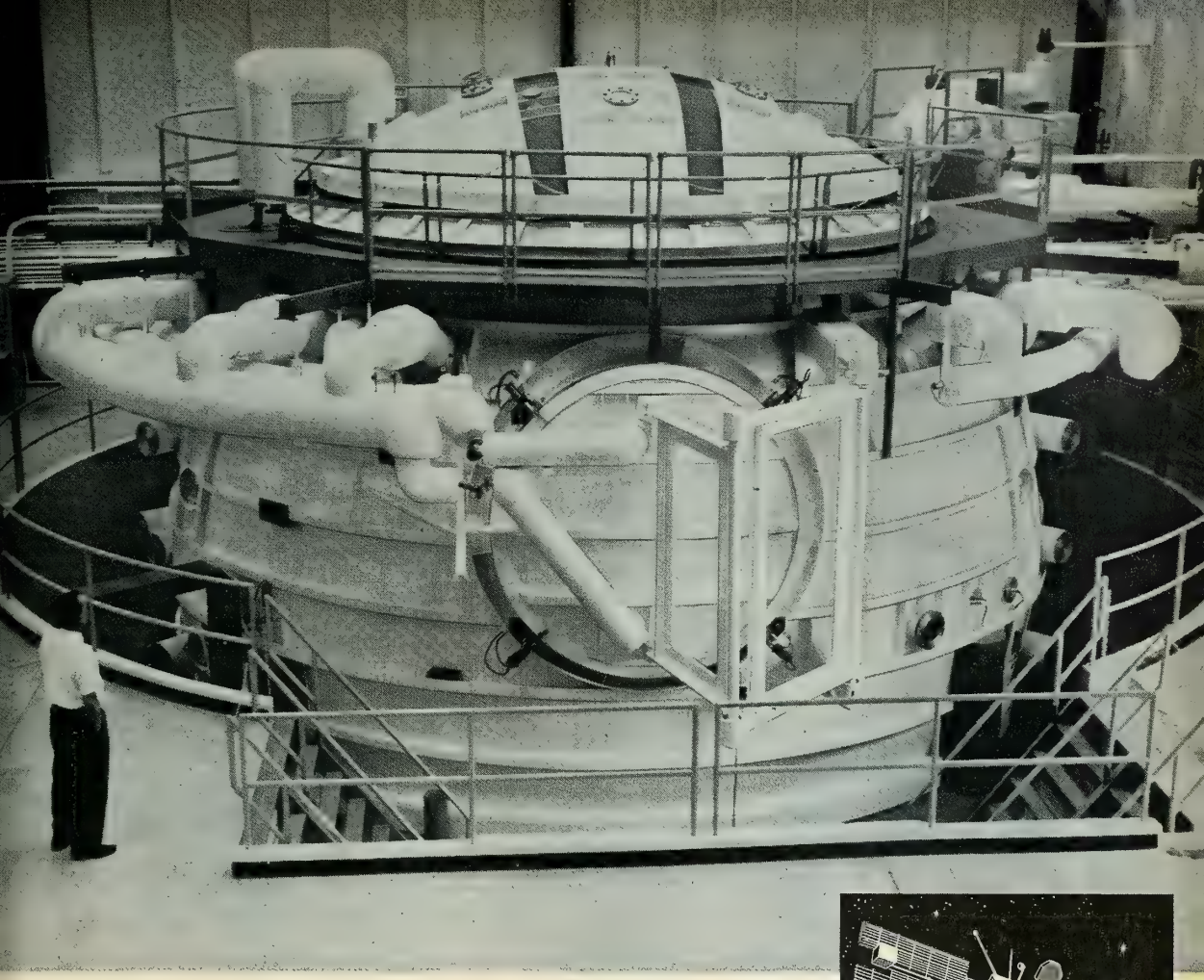
With a medium-altitude system, four sites would be built, three in the continental U.S. (one in the East, one in the West, and one in the Southeast) and one in Hawaii. With a synchronous system, the Southeastern U.S. site would not be needed.

Medium-altitude satellites will require multiple antennas for the "hand-over" problem as one satellite passes below the horizon and another takes its place in antenna view. Though synchronous satellite communications can be done with relatively fixed dishes, planners here feel that it would not be wise to forsake building of steerable antennas for use with syncoms in the interest of what might turn out to be wasted savings.

Because of its location, the Hawaii station would need two antennas to operate with a global syncom system. Though priorities have not yet been fully established, it is likely that pressure to get a facility on the West Coast, where a permanent antenna for these purposes does not now exist, would start the program there.

While the details for these stations are still to be spelled out, ComSat gave M/R its generally technical requirements. For one, the antennas used will be high-gain (55 db) 85-ft dishes, or equivalent aperture designs. The stations will use state-of-the-art, but "custom built," modulators and receivers for the wideband FM communications system. Maser receivers are to be used, and a system noise temperature of 50° K. is predicted for the worst case (lowest elevation), and perhaps as low as 25°-30° K. for the highest pointing elevations. Transmitter output is expected to be on the order of 5-10 kw. The basic transmitter/receiver equipment will be compatible with either type of satellite system.

In other ground station developments, the Japanese are now using a



OGO'S OUTER SPACE TEST TUBE A COMPLETE PROJECT BY CB&I

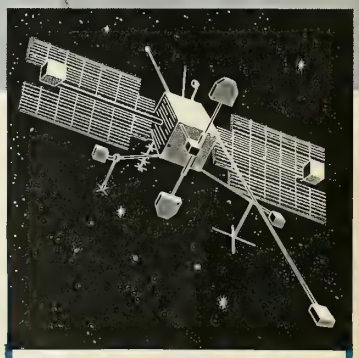
A new space simulation system which is now being used to test NASA's Orbiting Geophysical Observatory (OGO) spacecraft was completely designed and supplied by CB&I.

This is the largest system designed and supplied by a single contractor, without subcontracting the chamber, thermal system or vacuum system.

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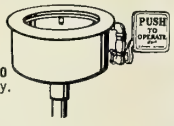
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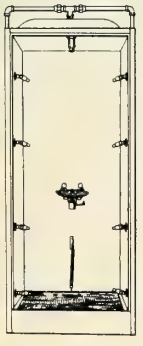
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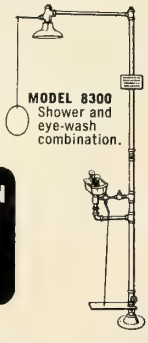
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60-ft. dish in experiments with *Telstar* and *Relay* and are also building a 90-ft. dish.

In order to place a synchronous satellite over the Pacific for use between Japan and the U.S., a West Coast station will be required in the U.S. and, perhaps even more importantly, the Japanese would have to decide whether or not sufficient circuit demand, in excess of that supplied by the first Japan-U.S. submarine cable laid this summer, would justify the cost.

The Swedes are also building an 85-ft. antenna, and there is a transportable 30-ft. dish in Spain built by ITT; however, neither of these are expected to use the *Early Bird* system.

• **R&D plans**—Whatever system ComSat decides to put into space, it does not merit the title of an "ultimate" system, with which it has often been tagged. Satellite improvements will have to be phased in in any case to meet the progressive demands of added channel capacity, longer lifetime, and better quality transmission.

To support these future needs, corporation planners are developing an R&D program. Discussing the areas of possible future funding with M/R, they point to:

—The attempt to explore the mechanical options for performing some traditionally electronic functions, such as the GE contract for a mechanically de-spun antenna (using a magnetic bearing).

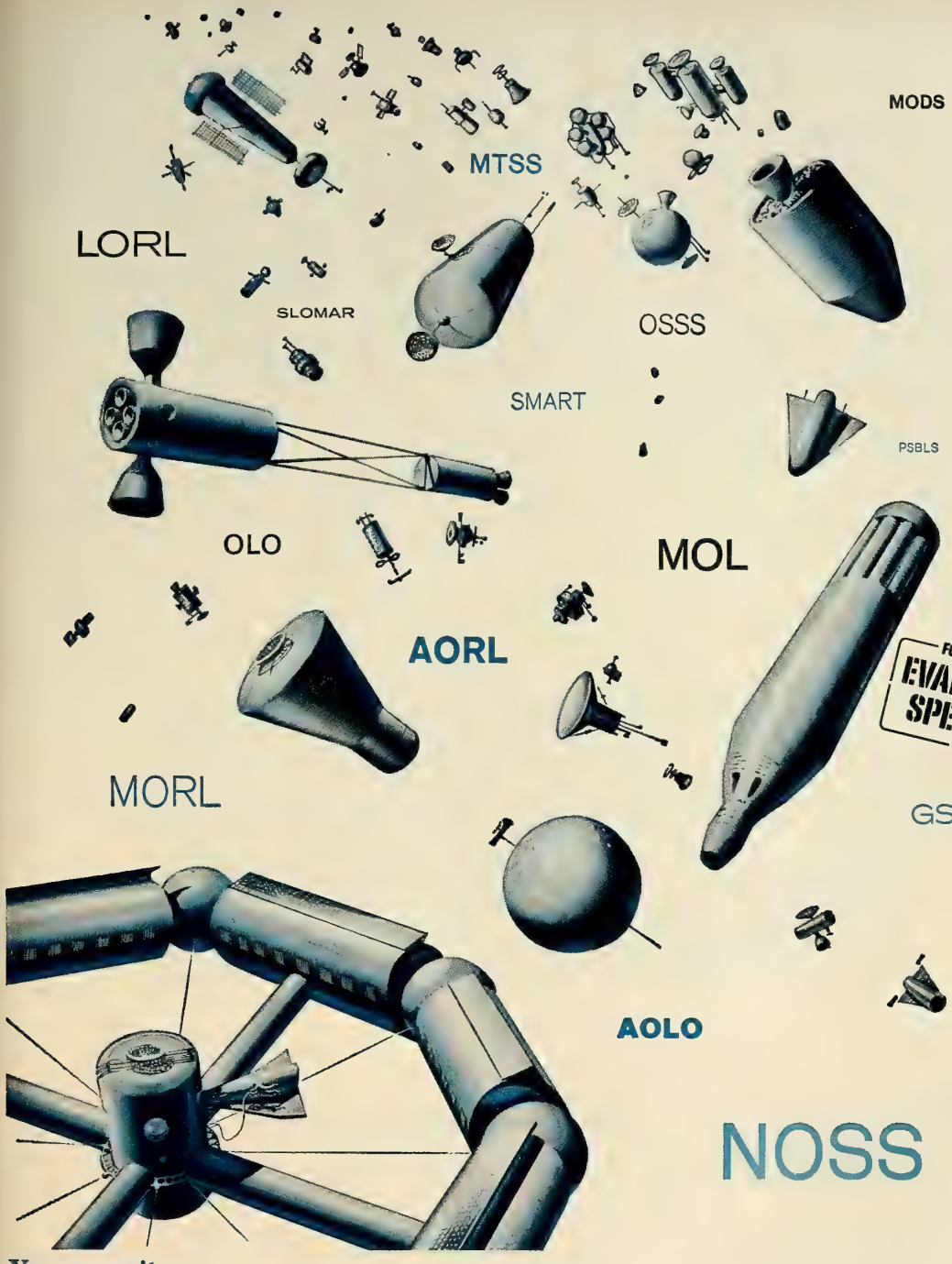
—For future satellites, ComSat will look into new automatic steering arrays which can respond to a ground station tone signal with a highly directional beam. This is akin to the retrodirective array systems (M/R, Sept. 23, 1963, p. 34) which have been worked on by Sylvania, Bell Labs, and IBM, among others.

—Development of higher power solid-state power tubes which could cut critical power supply weight aboard satellites. While ComSat will study this, they admit that nothing in this area can now approach the highly reliable traveling-wave-tubes developed in industry for power and efficiency. ComSat in its earlier days, funded studies on advances possible in the t-w-t field (M/R, Nov. 11, 1963, p. 35).

—The corporation will keep its eye on nuclear radioisotope supplies for satellites and new lightweight structures applicable to the design.

—ComSat is also apt to fund study of new modulation schemes which would have the effect of providing more channels per watt. New digital coding methods for use with time division schemes, which could follow frequency division in future systems, is one possibility. ■

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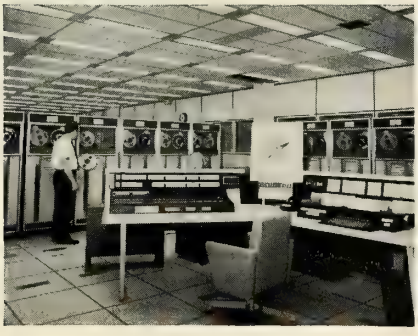


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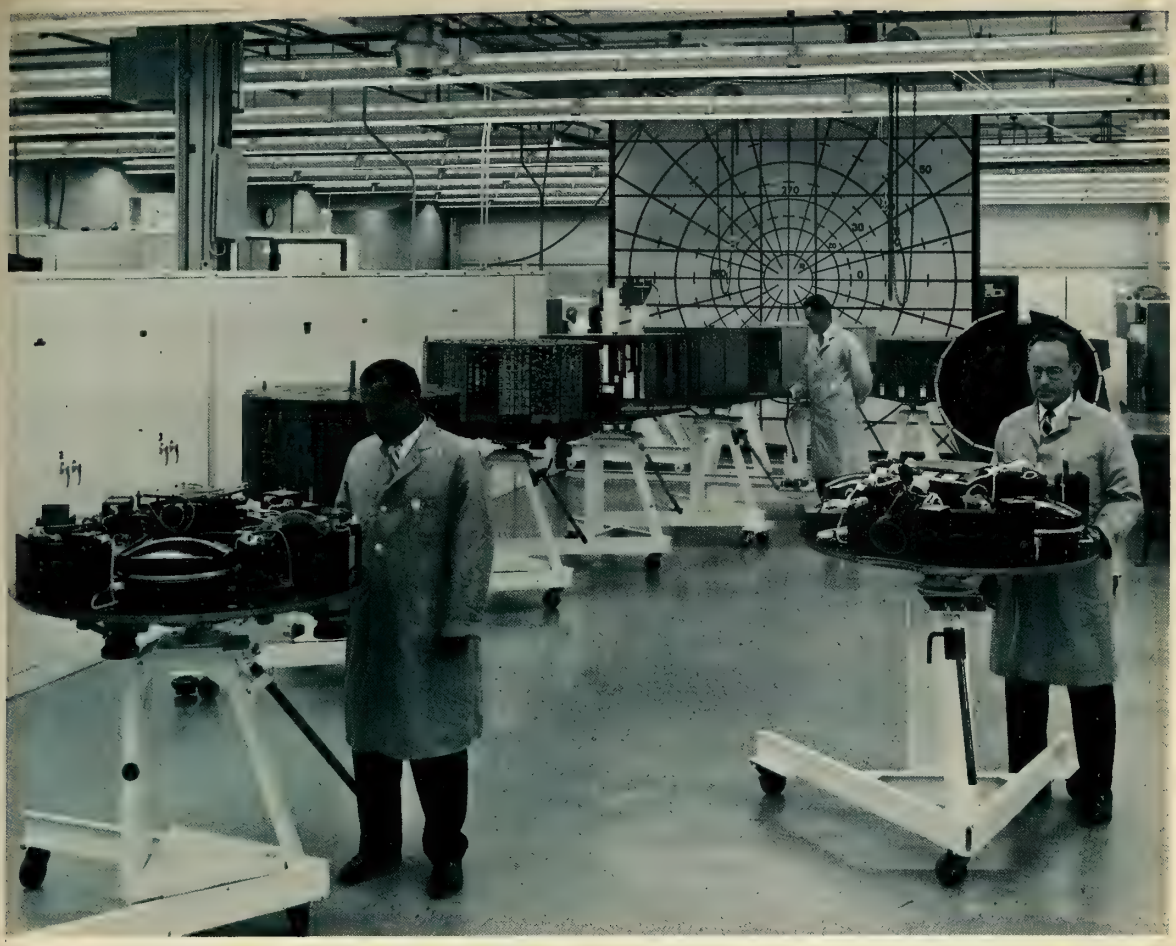
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RCA's TIROS Project Manager Abe Schnapf (right foreground) surveys the NASA "wheel" version Tiros baseplate, with cameras canted 26.5°. It will fly early next year. Conventional baseplate, with cameras protruding beneath, is at left.

Part IV

SPECIAL REPORT: WEATHER BUREAU

Bureau's Spending Level Will Climb Over $40 Billion During 1970's

Chief calls satellites' potential 'overwhelming'; expected developments include isotopic power for Tiros system, unprecedentedly sophisticated instruments

AN ISOTOPIC power supply for the *Tiros* operational satellite system, cameras with 3-5-yr. lifetimes in orbit and new instruments capable of making meteorological measurements never before obtained remotely are among the avenues of new technology being considered by officials of the Weather Bureau's National Weather Satellite Center (NWSC), Suitland, Md.

Center Director David Johnson says the Bureau's spending level will be between $35 million and $40 million for the duration of the *Tiros* operational system (TOS), but that an upturn can be expected sometime after 1970 with the switch to an advanced system. This system would be based on a new satellite, and would have more ground stations and data points than TOS.

Isotopic power supplies appear attractive to the Bureau as replacements for the present *Tiros* solar cell system, which is vulnerable to radiation at its 750-n.mi. operational altitude. Radiation damage can shorten the Radio Corp. of America-developed *Tiros* satellite's already limited lifetime.

Isotopic power also promises to be the key to extending camera lifetime.

Expenditures for meteorological satellite programs for Fiscal Year 1966 will constitute about one-third of the entire U.S. Weather Bureau Budget, Johnson told MISSILES AND ROCKETS. The National Weather Satellite Center (NWSC) will ask about $40 million for metsat programs this year and each succeeding year at least through 1970.

The potential role of satellites in the Weather Bureau's work is "overwhelming," U.S. Weather Bureau Chief Dr. Robert M. White told M/R. "It is hard to visualize any other kind of platform that would be able to get the kind of information we need as economically or as comprehensively.

Since his appointment as Weather Bureau chief a year ago, White has stressed technology developments. While the Bureau has been a leader in exploiting technology, even more work could be done, White says.

White indicated a need for increased efforts in areas of new observational techniques and communications systems, more procedures such as automatic weather stations and greater use of computers in weather data analysis and forecasting. He also emphasized the need for early determination of the feasibility of a data-collection satellite, and the fullest exploitation of satellites as world-wide observation platforms.



DAVID S. JOHNSON, director, Weather Bureau's National Weather Satellite Center.

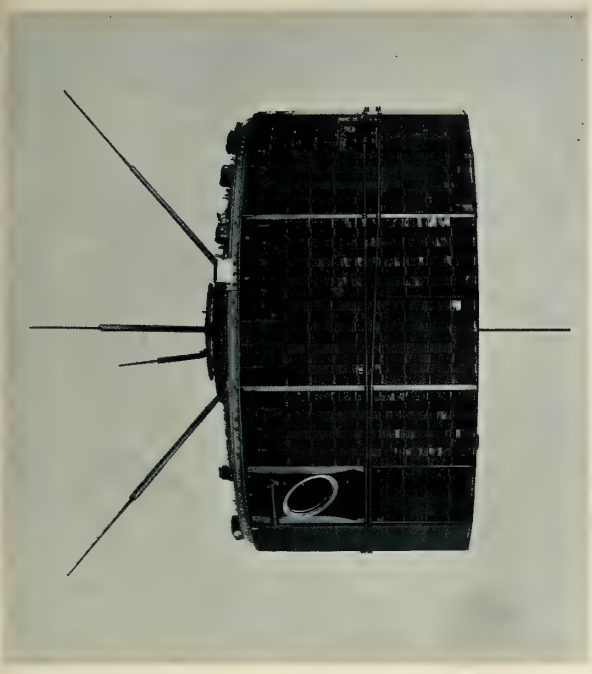


DR. ROBERT M. WHITE, chief of United States Weather Bureau.

TIROS OPERATIONAL SYSTEM

The TOS satellite, like the earlier *Tiros* satellites, is being built by RCA and will carry RCA cameras. The Weather Bureau is initially obtaining five TOS satellites in addition to interim spacecraft. NASA is the Bureau's procurement agency in these transactions. These will be designated *TOS-A* through *E*. NWSC officials said that funds are available in FY 1965 for three additional TOS spacecraft, but procurement is being deferred until later in the Fiscal Year in order to incorporate the latest technological advances.

The *Tiros* "wheel" increases the coverage from four to five times the original *Tiros* satellite return.



CARTWHEEL configuration of Tiros satellite. Earth-stabilized, five of this type are to be launched, serving as an interim operational system. "Wheel" increases coverage of original Tiros by factor of four or five.

• **TOS timetable**—The first *Tiros* operational satellite will be launched in the first quarter of 1966. This will be *OT-2*, to be placed in a 750-n. mi. circular orbit from Cape Kennedy by the improved *Thrust-Augmented Delta* launch vehicle. Orbital period will be approximately 113 minutes, and Sun-synchronized so that the same Sun time prevails on each pass over a certain latitude. As with *Tiros*, RCA is prime contractor.

Like *TOS-B* and *-D*, *OT-2* will carry two Automatic Picture Transmission (APT) camera systems. This system photographs the Earth once every 208 seconds and takes 200 seconds to transmit each picture.

About two months after launch of APT *OT-2*, a companion spacecraft, *TOS-A*, will be launched into a circular, near-polar orbit at 750-n. mi. This spacecraft, like *TOS-C* and *TOS-E*, will carry two advanced vidicon camera systems (AVCS) like those carried on *Nimbus*. This will be the first use in the TOS system of the one-inch vidicon, which has 800-TV-line resolution. Picture resolution directly below the camera will be 1.5-n. mi. per line. From the TOS altitude, photographs will cover regions 1,736-n. mi. on a side, thus providing global coverage.

The RCA cameras in both *OT-2* and *TOS-A* can be used alternately, thus ensuring increased operational lifetime.

The AVCS spacecraft (*TOS-A*), according to Johnson, may also carry an infrared experiment developed by Dr. Verner Suomie, on leave from the University of Wisconsin and now the Weather Bureau's chief scientist.

The experiment, which is planned for at least *TOS-A*, consists of a hemispheric sensor on a flat plate which integrates all the radiation it receives. While it is not the HRIR of *Nimbus*, it will enable the scientists to detect major storm centers at night, and check on those observations made in the daylight.

It also will contribute to the planetary heat-budget record being kept not only for 30-day forecasting but as a record of climatic change. The very crudeness of the kind of experiment imposed by the limitations of the TOS satellite is actually a boon for this application, since the "dribbles" of data are easier to handle.

Before the inauguration of the official TOS system, however, several launches are planned. *Tiros-I* (eye), which will be designated *Tiros IX* if successful, is to be launched in the first quarter of 1965. This satellite, a NASA vehicle, will be the first to be put into polar orbit from Cape Kennedy, and the first cartwheel satellite.

Plans are to put it into a Sun-synchronous, 81° retrograde orbit through a series of dog-leg maneuvers. The cartwheel should roll at from 8-12 rpm, and will use a magnetic spin-control coil to maintain speed and attitude, so that the cameras will operate when pointed toward the Earth.

Although NASA also will be launching a number of its own R&D satellites next year, the Weather Bureau will fund one more (*OT-1*) for possible launch next summer, to provide operational coverage during the hurricane season. *OT-3*, a backup to *Tiros IX* should the NASA satellite fail, also is a cartwheel carrying two one-half-inch vidicon cameras. Altitude will be 400 n. mi.

• **Ground stations**—During the entire duration of the TOS system, Johnson said, no new command and data acquisition stations will be needed. However, the method of operation will be changed. TOS data received at Gilmore Creek, Alaska, and Wallops Is-

Budget Sustained by Carryovers, Nimbus Refund

THE NATIONAL Weather Satellite Center has had one of the most confusing budget pictures since its inception, partially because of the fact that it had bought into the NASA *Nimbus* program, and received a refund when it pulled out.

In FY 1962, the first actual budget year, the satellite program was given $48 million from Congress, of which it spent $47.8 million and had $193,000 left over.

In 1963, it received $40 million, making a total available of $40,193,000. During FY 1963 it obligated only $11,639,000, leaving $28,555,000 unobligated.

For FY 1964, no money was asked, nor any appropriated by Congress. However, the Satellite Center recovered $5 million from the so-called *Nimbus* operational systems (NOS) funds it had turned over to NASA. This added to the carryover, making $33,570,000 available. The Satellite Center then obligated $31,739,000, leaving $1,831,000.

This year, FY 1965, the Congress gave the Satellite Center $10 million, which, with the carry-over, gives the Bureau $11,831,000. However, NASA also refunded more than $22 million from the NOS money, making available a total of $32.9 million for FY 1965. According to Center officials, all but $1.1 million probably will be spent by the end of the year.

In addition, the Center is allotted research funds, which are included in the Weather Bureau's research budget request. The figure for FY '65 is about $2 million.

land, Va., will be recorded on magnetic tape and widebanded to the NWSC in Suitland. The Satellite Center's Data Processing and Analysis Facility, developed for the *Nimbus* operational system for which the Weather Bureau cancelled plans last year, will, with modifications, handle TOS because of its use of the *Nimbus* camera systems. All the analyses will be done in this central location and relayed out for use.

The decision to consolidate the command and data-processing activity at Suitland rather than continue the operations at the field stations was made for reasons of efficiency, improvement in the product and meteorological content and quality control, Johnson said.

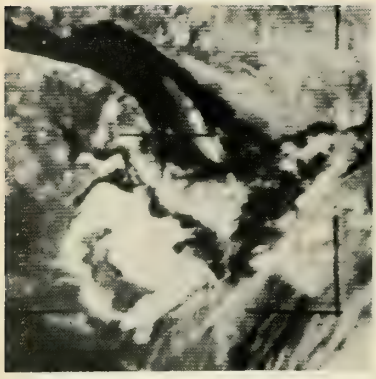
Eventually these ground stations will now be taken over by the Weather Bureau, instead of operated by NASA.

● **Improved TOS**—Although the first TOS satellite has not yet been launched, Weather Bureau officials are already looking ahead to improvements in the system. One of the biggest concerns has been the effort to increase operational life.

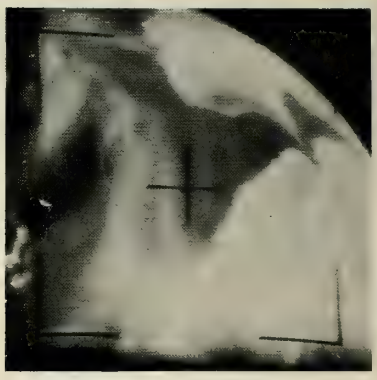
The Atomic Energy Commission has contracted with the Martin Co. for a feasibility study of the use of a SNAP-19 isotopic power system for the TOS spacecraft. No Weather Bureau funds are now being used.

As it is presently envisioned, the TOS satellite probably would require two SNAP-19 isotopic power sources, since each provides about 30 watts. The SNAP-19, being developed for an experiment on *Nimbus B*, is expected to weigh about 25 lbs. per unit, and is fueled with plutonium 238.

Such a system, Weather Satellite







LEFT AND CENTER: Two shots from series taken during Phase II of Project TIREC (Tiros Ice Reconnaissance), joint U.S.-Canadian effort. Area is Gulf of St. Lawrence; white is ice. RIGHT: Tiros VI shot of dust storm over Arabia.

Weather Satellites Promise Data for Many Other Purposes

ONE OF THE ramifications of the operational satellite program for weather forecasting is the potential for providing operational information useful for other purposes. While supplying the many potential users has not yet been a problem, some decisions on how to make this information available will have to be made as the amount of data increases.

One of the side uses of *Tiros* photographs that already has had operational application is in ice reconnaissance. Now supplied by mail, the data has been in great demand by Canadian shippers in the Great Lakes area. This function has thus far been handled by the Detroit Weather Office.

Ice and snow photographs also have great potential for flood control and reservoir management. Although snow pictures can be confused with cloud-cover photographs, they can be distinguished by comparing photos from successive passes. Biggest users of such information could be western states that depend on spring runoff for irrigation purposes. Such measurements are now made manually.

These pictures also have great application in long-range forecasting, since they contribute to the total heat budget. This information is also fed to the Extended Forecast Group of the Weather Bureau.

When infrared is used operationally, Weather Bureau scientists say, the satellites should also be able to spot forest fires in remote areas. These fires, it is estimated, cost the U.S. between $50 and $300 million in losses each year, and an additional $140 million a year for control.

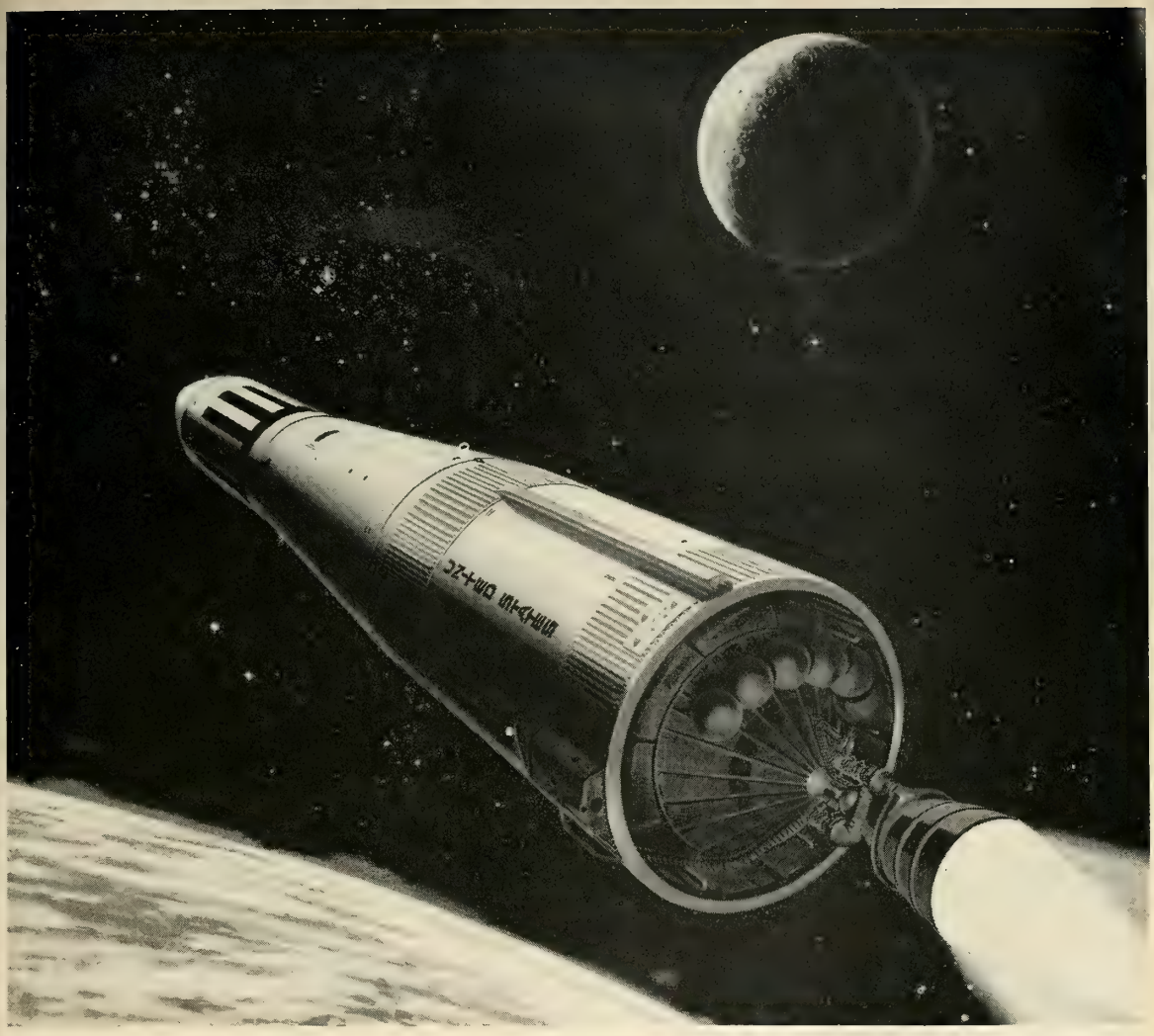
Tiros data has already proven itself valuable in the problem of locust control in areas of Africa and Asia. As Dr. S. Fred Singer, former head of the NWSC said, locusts are a "semi-meteorological" phenomenon, since they are carried by the wind. Satellite data can be used to predict winds in equatorial zones, which have few weather stations. Annual costs for locust spotting and control, Singer said, is about $15 million.

A potential use being investigated is in observations of the state of the sea. This, however, is hard to lock onto, since the observation must be made with the optic axis inclined the same as the Sun, to get the reflection of the Sun. The character of the image in the photograph then indicates the sea state. TOS, with its Sun-synchronous orbit, is expected to get more useful data.

Through *Tiros* photographs, growing confidence also is being felt about ability to determine the exact location of the jet stream.

In the interests of basic science, meteorological satellites are furnishing for the first time a world-wide record of climatic conditions, which is being achieved for long-range study.

Weather Satellite Center scientists are now faced with the problem of preparing to store these vast amounts of data for at least 200 years. Only through study of long periods, scientists say, can it be determined whether the Earth is warming up or not, or whether recent observations are simply short trends. This project actually is causing a mild technological problem, since magnetic tape will not hold up that long. Digital data is now being converted to film for storage.



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Center officials say, could provide a lifetime of from three to five years, depending upon how much fuel is carried. They are aiming at a 1967 or 1968 target date for the operational system.

• **RTG tested**—RCA also is developing a radioisotopic thermoelectric generator (RTG), which could be used on the *Tiros* spacecraft. This system has been tested at the Atomic Energy Commission for several months. It has a 30-40-watt output with a strontium source. The unit would sit on top of the *Tiros* "hat," *Tiros* project leader A. Schnapf told M/R, and would not damage or interfere with the electronics in the spacecraft. In-house studies also are going on probing the problems of adapting nuclear power operation to *Tiros*.

The Weather Bureau also is pressing for developments to extend the life of the APT and AVCS camera systems to match the possible 3-5 year lifetime.

RCA is studying methods of combining the two types of systems into one unit. There are two possible techniques, Schnapf said—one taking the AVCS data and transmitting it slowly; the other taking APT data and transmitting it rapidly.

RCA also is looking at means of extending the life of the APT units, especially in the area of techniques to preserve the photoconductive material.

In the controls area, the RCA Astro-Electronics Division is developing gyromagnetic techniques to maintain attitude over long periods of time, using a minimum of power and with few electronic parts. While this is not a program-oriented development, it could be applied to *Tiros*, Schnapf said.

NASA, RCA and the Weather Bureau also are looking at integrated circuitry to reduce drastically the electronics package. Schnapf estimated that an 80% reduction could be attained in the camera system electronics. Some study contracts are now out on the AVCS and APT systems.

The success of *Nimbus A's* high-resolution infrared system has already accelerated thinking about the need for good operational infrared data from the TOS system. While the HRIR cannot be adapted because of size, weight and power limitations, something in the "intermediate range" is now being contemplated.

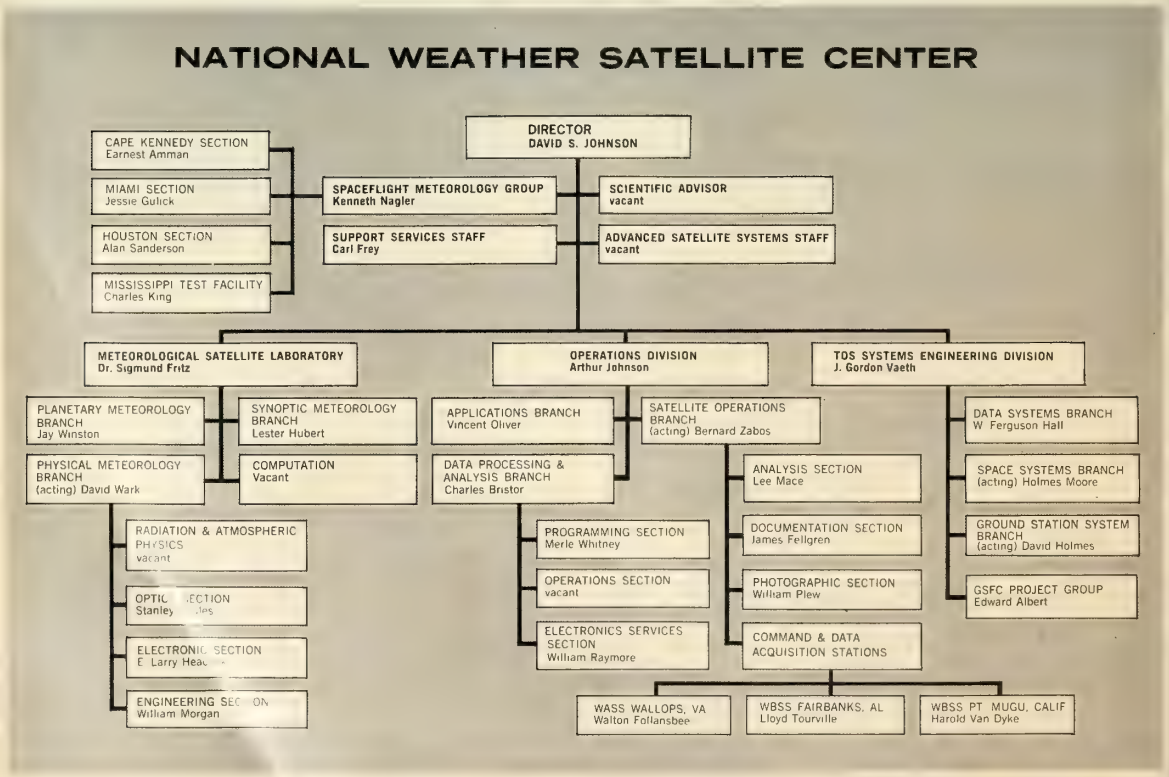
On the long range view, Schnapf points out that the new fairing on the *Thrust-Augmented Delta* stage allows a satellite diameter of perhaps six inches more, should the Weather Bureau wish to enlarge the size of the vehicle.

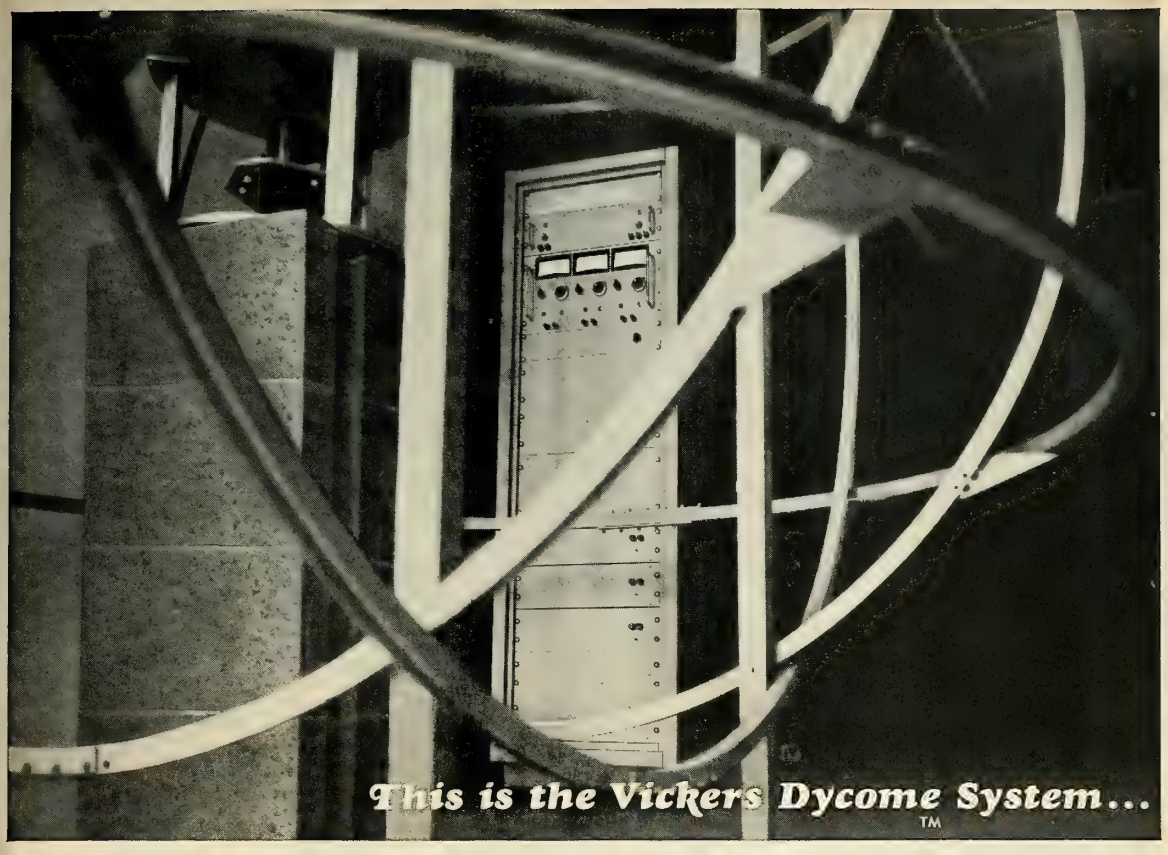
• **New experiments**—A number of studies are being conducted in-house at the Weather Satellite Center on new types of experiments that could be useful on meteorological satellites. In all cases, the Weather Bureau, if it wishes to do research for its own needs, funds the project only up to the flight prototype stage. It then asks NASA to incorporate the experiment into a satellite test, for which NASA handles procurement. If the experiment is then assigned to an operational satellite, NASA continues procurement at the Weather Bureau's request, and handles launch details.

One such experiment that shows possibilities of being incorporated into a meteorological satellite at some later date is an infrared spectrometer that will measure radiation emission from carbon dioxide in the atmosphere. Data on the vertical temperature distribution can then be obtained. An additional sensor in the 11.1-micron band will provide the black-body temperature of solid objects, and give cloudtop temperatures.

This instrument, which was tested at 100,000 ft. on a balloon at Palestine, Tex., is in the pre-prototype stage and "looks very promising." Next step, according to Director of NWSC Metsat Lab Dr. Sigmund Fritz, is to ask NASA to contract for a flight prototype for test on a satellite, probably *Nimbus B*. The contract probably would be broken down into three areas: frame and mechanics, optics, and electronics.

If the satellite test is successful, Bureau officials say, the equipment prob-





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VE93-2

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AVCS PHOTOGRAPHS recorded at RCA Astro-Electronics Div., Princeton, N.J. At left is C. Martinelli, RCA engineering leader for the Tiros program. At right is Abraham Schnapf, RCA manager for the weather satellite program.

ably will be cranked into a follow-on operational system.

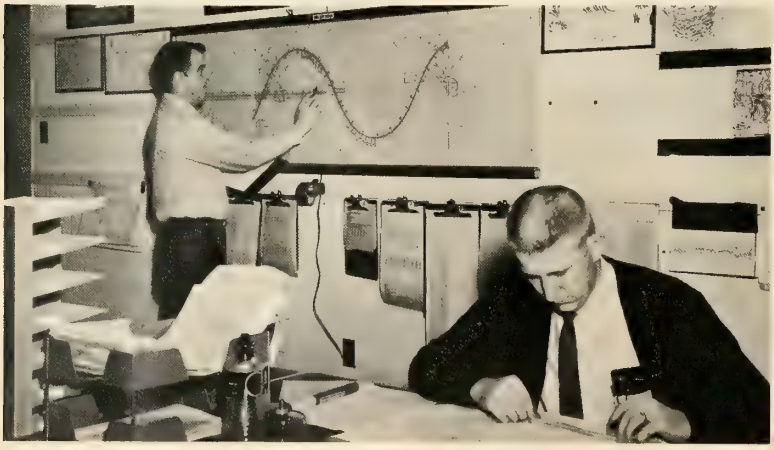
Another instrument being developed in-house at the Satellite Center is a simple spectograph to measure oxygen absorption spectra in the 7,600-Å band. By obtaining this measurement, which is a function of path length, the distance to the cloud top can be determined. Thus cloud top height can be reckoned independently of its temperature.

This instrument has been designed as a hand-held unit, which is now flight-qualified and scheduled for the second manned *Gemini* flight. During this flight, the astronaut will take a picture of the area below, at which time a spectrogram is simultaneously recorded. If this proves feasible in this *GT-4*, it will be considered for metsats. However, it will have to be modified for manned vehicles.

DATA COLLECTION

The next big breakthrough, Manager of NWSC TOS Engineering Systems Div. Gordon Vaeth feels, will be the combination of the observing function with the communication function.

WEATHER BUREAU personnel at the National Weather Satellite Center determine the track of the meteorological satellites.



Dr. White indicated that this, as soon as technology permits, has high priority in Weather Bureau planning. The Bureau has already asked NASA to do a data-collection experiment, which is scheduled for *Nimbus B*.

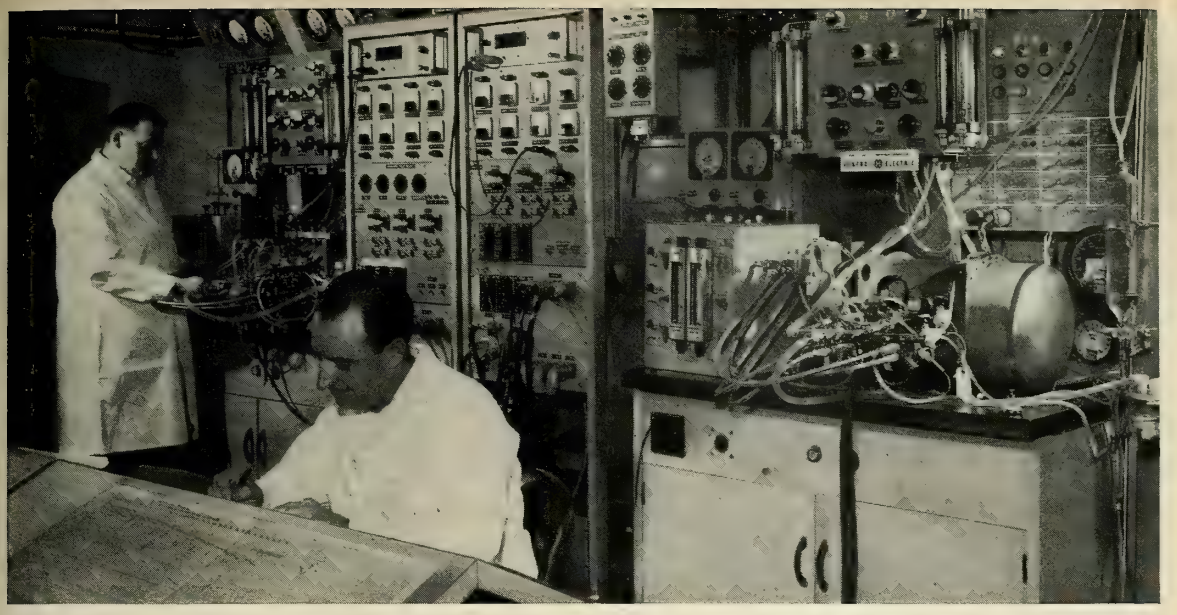
Meanwhile, the Weather Bureau is conducting its own supporting research. Although such things as automatic weather stations are envisioned for the future, one program is going ahead to study the uses of balloons.

Theoretically, tracking a world-wide network of constant-level balloons could give exact wind information. Wind information is one of the most important inputs to weather forecasting and global wind information cannot be obtained even with satellites unless special techniques are used.

Eventually, operational deployment probably would consist of several thousand balloons.

The study is now concerned with such details as cost of balloons, lifetimes, and air-traffic problems.

Another possibility being discussed is the use of buoys. According to Vaeth, the Weather Bureau would greet with open arms a contractor proposing a simple, inexpensive, and long operating life meteorological buoy capable of being accurately emplaced by aircraft. For this purpose, in remote-mid-ocean areas, the large rigid airship appears to hold economic and technical promise for emplacement, retrieval, and on-board servicing of the buoy.



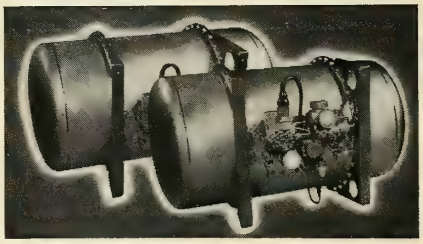
General Electric production-line fuel cell batteries "fly" 750 test orbits

Running through three successive 14-day Gemini 2-man spacecraft missions (equal to five times the distance to the moon and back) in a pre-flight test, the production-line fuel cell battery* (above, right) has demonstrated the long life capability of G-E fuel cells. Another fuel cell battery (above, left) met the more rigorous power requirement of shorter missions in which the Gemini spacecraft will meet an Agena vehicle in space. It successfully passed the test, delivering more than a kilowatt of power. Both units were stopped and restarted up to seven times as part of the planned test.

The two General Electric fuel cell batteries that will deliver up to 2-kilowatts of electric power and water aboard the Gemini spacecraft are simple (no rotating parts), light (70 lbs. per 1-kw unit) and inherently reliable as proven by these tests and others in which 32-cell modules have operated up to 70 days. General Electric fuel cell batteries have also been selected to provide electric power for NASA's Biosatellite spacecraft.

Fuel cells for future applications in advanced research stage.

While the above fuel cell batteries use hydrogen and oxygen and were specially developed for use in space, G-E's laboratories are at work



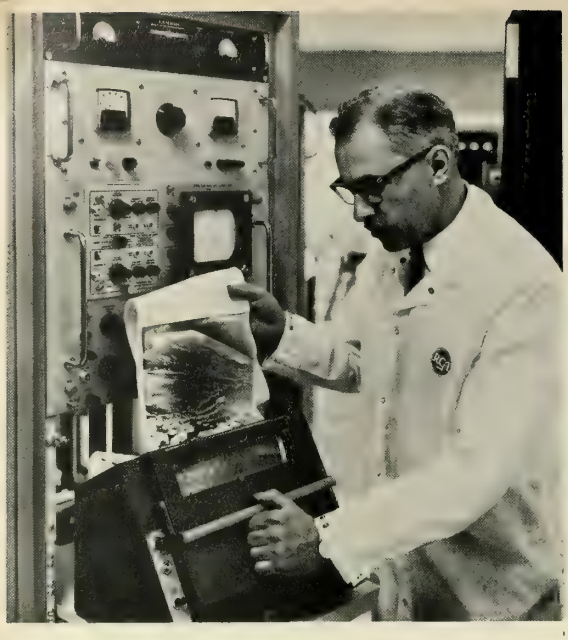
not only on longer-life versions of these but also on other types of fuel cells. Some of them are capable of directly converting common hydrocarbon fuels and other special fuels to generate electric power. Advanced work is also being done in the field of thermoelectric energy conversion.

What does all this mean? Simply—that General Electric's production fuel cells are ready for flight validation and that G-E continues to be a leader in carrying fuel cell technology toward wide practical application in space, on land and sea, including—eventually—many industrial uses. 183-16

*** Developed for McDonnell, prime contractor for the Gemini spacecraft to NASA's Manned Spacecraft Center.**

GENERAL ELECTRIC

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LEFT: Weather pictures from Nimbus satellite's RCA APT camera system will be automatically transmitted to small ground stations where they will be reproduced on facsimile similar to the one shown. ABOVE: APT camera is 13.10 in. long and has total weight of 20 lbs.

The ideal system would have buoys deployed world-wide in a grid about 180 mi. apart, although a barely operational coverage probably could be obtained at points located as far apart as 800 mi.

There is also a great deal of interest in using an advanced system such as *Syncom* for the communications function. Many bottlenecks are present in getting meteorological information out throughout the world while it is still useful.

ADVANCED SYSTEM

The Weather Satellite Center now has a core of full-time engineers and meteorologists under Vaeth who are working on concepts for an advanced operational system.

Meteorological requirements are being gathered from all interested agencies, and the search is on for new applications of new technology.

In general, Johnson said, the Weather Bureau wants a satellite that would permit more and different kinds of observations, night-time data, the bility to read out night-time data both day and night, cloud-top temperatures, temperature profile, motion in the atmosphere and ability to communicate meteorological data quickly.

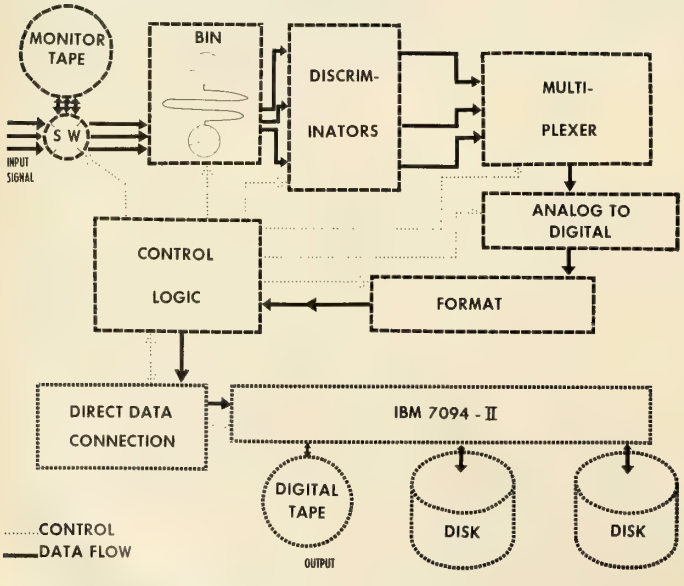
According to Johnson these requirements probably will be completed within six months to a year.

While no commitment is being made to a synchronous satellite system, some feel that it will be necessary.

This would be the only platform giving the opportunity to watch the passage of meteorological phenomena over the same spot on the Earth.

In addition to the experiments NASA will conduct on its own satellites, a number of supporting studies are being conducted on the kinds of meteorological data that could be obtained from synchronous altitude.

In the final analysis, however, the Weather Bureau will give NASA only a breakdown of what meteorological observations it wishes to make at what frequency in time, rather than systems requirements.



FLOW DIAGRAM shows how vidicon pictures are processed digitally.

● **Launch vehicles**—Some interest has been indicated in multiple-launch capability, although the Weather Bureau also leaves this kind of decision to NASA. Another desirable feature other than the synchronous altitude, is a somewhat higher altitude for the TOS system, at perhaps 1,000-1,500 mi. The improved *Delta,* however, is expected to last through the TOS system.

MANNED METSATS

Taking a really long-range view, officials at the Weather Bureau em-



Cubic SECOR satellite surveyor makes first direct coast-to-coast measurement of U.S.

Cubic's SECOR, world's most precise satellite tracking system, recently completed the first direct "single-leap" distance measurement across the United States, from San Diego, Calif., to Herndon, Va. In only 10 seconds, the distance between these points was determined to be 3,628,300.5 meters, or 2,254.5 miles.

More important than actual distance computation was SECOR's ability to accomplish this historic feat. SECOR uses a satellite 600 miles in space to plot and measure the earth with amazing speed and surveying accuracy.

"...a first order geodetic tool..."

After initial tests, SECOR won the highest praise of the surveying and mapping profession.

Army officials noted, "SECOR has the full capability of a first order geodetic tool." In present operations, Cubic's all-weather SECOR system is successfully measuring distances between points of land separated by broad expanses of ocean.

29,000 "ranges" in six minutes...

During a typical satellite pass of six minutes duration, SECOR's four Cubic-built ground stations make approximately 29,000 measurements or "ranges" with 95% success. Within the SECOR satellite, a miniature 7-lb. Cubic transponder acts as a receiver-transmitter.

Tests prove that SECOR can extend control over distances exceeding 2000 miles with geodetic accuracy.

SECOR's far-reaching applications...

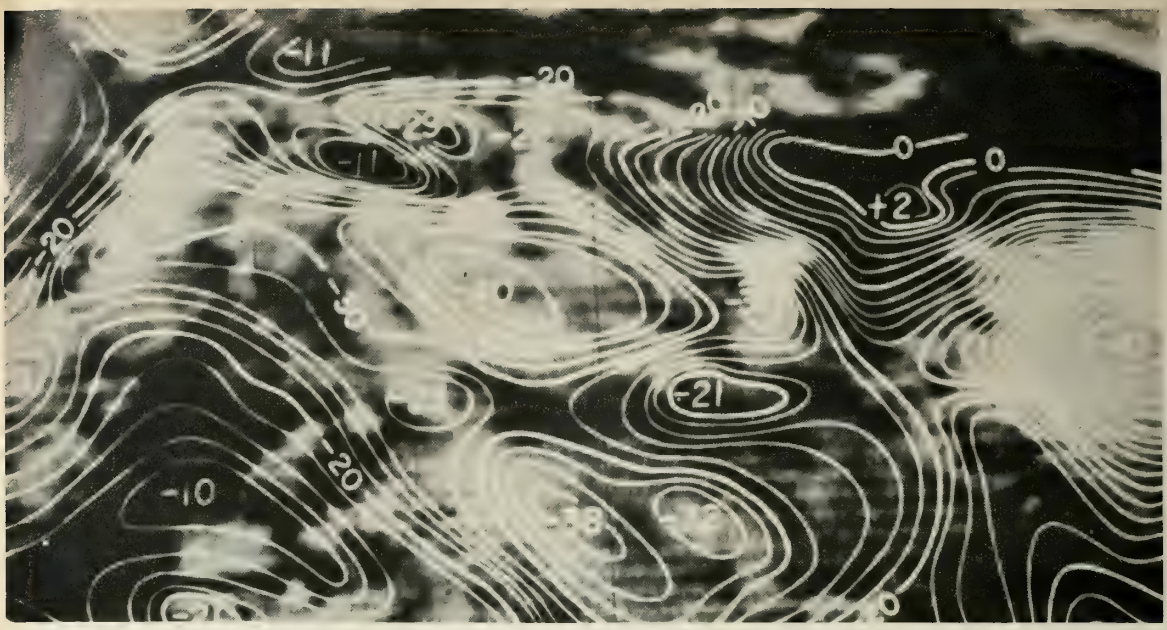
Data gathered by Cubic's SECOR will have lasting importance in the fields of geodesy, global navigation and satellite navigation. SECOR will have a role of major importance in space and defense programs requiring distance measurements with pinpoint accuracy. Information about the earth's shape and gravitational field is also being obtained.

SECOR is a product of Cubic Corporation, leader in the field of electronic measuring systems.

For additional information about SECOR, write to: Chief Scientist, Cubic Corporation, Department C-231, San Diego, Calif. 92123.

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PART OF RESEARCH on mathematical formulae for comparing height of clouds. Photo taken by Tiros over north coast of Africa and the Mediterranean Sea. Project performed by Dr. Tetsuja Fujita, University of Chicago meteorologist.

phasize the eventual need for manned space weather stations.

Besides all the ramifications of manned satellites for basic research studies in meteorology, man would greatly enhance an operational system, they say, as a screener of unessential information to concentrate the observational effort. He also could calibrate complex instruments and confirm automatic experiments.

In addition, he would be valuable in reporting unusual events for which no instruments have been designed.

The Weather Bureau has worked closely with NASA in training astronauts to make certain meteorological observations, and is urging meteorologists to apply to the scientist-astronaut group. The manned spaceflight branch of the NWSC, headed by Kenneth Nagler, also is responsible for advising NASA on meteorological conditions of landing and launch sites.

SUPPORTING RESEARCH

In addition to work on those instruments already considered potentially suitable for inclusion on spacecraft, a number of laboratory and theoretical studies to support planning of future experiments and even design of spacecraft systems is conducted by NWSC.

Considerable study, for instance, has gone into the 15-micron region CO_2 band both here and in Japan, to determine its parameters. This and the rotational water vapor band are considered best for horizon sensing for satellite cameras.

Another study is aimed at determining the feasibility of measuring ozone in the ultraviolet spectrum (3,000 Å). Ozone calculations as a function of height can be obtained by measure-



DATA PROCESSING and Analysis Facility of the National Weather Satellite Center at Suitland, Md.



Man: the ultimate computer for space missions

Why should a scientist, weighing a satellite's pound-precious payload, allot 160 pounds of it to a man? Couldn't a 160-lb computer do a better job?

Fair questions — for the computer is rapidly becoming smarter, swifter, smaller. Indeed, the art of microminiaturization already has shrunk suitcase-size components to dime-size.

Yet a computer that could match only a fraction of man's total capabilities would be so huge that no rocket known today could boost it into orbit. Even if such a computer could be orbited, the cost would be crushing—for the economics of space are based on the price of orbiting each pound of payload. And it still would lack man's ability to react to the unforeseen emergency, reply to the unexpected question, repair the faulty mechanism—or make a choice. So the scientist must make room in the satellite for the ultimate computer: man.

Lockheed Missiles & Space Company has been at work for seven years on the problem of utilizing man's unique capabilities in space. In more than 125 launches to date, Lockheed's Agena space vehicle has orbited almost every size and shape payload, setting world standards for precision and reliability. Lockheed's Human Factors group has made significant progress in overcoming the problems and hazards of space travel. And Lockheed's Man-in-Space group has designed an earth-orbiting manned laboratory to determine which missions can be entrusted to computers and which must be done by man.

LOCKHEED

Lockheed Missiles & Space Company, Sunnyvale, California: A Group Division of Lockheed Aircraft Corporation.

CAREER OPPORTUNITIES in GUIDANCE AND CONTROL SYSTEMS

Important new contracts have created additional openings in the field of guidance and control. United Aircraft Corporate Systems Center needs engineers in many phases of G&C development programs involving complex aerospace systems. The following are typical positions now available at both senior and junior levels.

ELECTRONIC DESIGN (SENIOR) — requires degree in E.E. or Physics. Experienced (7 to 10 years) in methods, processes, materials, and components used in designing and manufacturing electronic equipment. Will be responsible for reducing breadboard models to final thin film and monolithic integrated circuit hardware which will meet final spec requirements on environment, reliability, etc.

INSTRUMENTATION ENGINEERING — requires E.E. degree. Experienced (3 to 7 years) in instrumentation application, analog and digital equipment, data processing, and data recording equipment. Experience with inertial equipment desirable.

SYSTEM INTEGRATION AND TEST — requires E.E. or M.E. degree. Experienced (1 to 5 years) in development of inertial guidance systems or inertial components. Will perform development testing on inertial systems, including test design, performance, and analysis of results.

THERMODYNAMICS (SENIOR) — requires degree in M.E. or Physics (M.S. desirable). Experienced (7 to 10 years) specifically in heat transfer relating to electronic and other aerospace equipment. Must be familiar with computer programming techniques, and weight and power trade-off studies. Will be expected to contribute to design and development of sophisticated thermal control systems.

ELECTRONIC DESIGN — requires E.E. degree. Experienced (1 to 5 years) in design and development of D.C. amplifiers; precision electrical measurements; pulse and digital circuitry; switching regulators; and monolithic integrated circuits and thin film techniques.

SENSOR DEVELOPMENT — requires degree in E.E., M.E. or Physics. Experienced (3 to 5 years) in development of inertial guidance components, including gyros, accelerometers, and associated electronic signal and control devices.

TEST EQUIPMENT ENGINEERING — requires M.E. degree. Experienced (3 to 5 years) in design of facilities and test equipment for electronic/inertial testing of guidance systems, subsystems, and components. Knowledge of electronics associated with such equipment desirable.

SYSTEMS ANALYSIS — requires E.E. or M.E. degree (M.S. desirable). Experienced (2 to 5 years) in analysis of guidance and control subsystems; performance evaluation; formulation of analytical models; and test planning and evaluation.

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ments of the scattered sunlight in the zenith by spectrophotometer.

In another project, although the Weather Bureau is no longer funding it. it is furnishing considerable advice to investigators at the University of Wisconsin who are developing a sferics (measure of lightning) experiment for a NASA satellite.

The University of Wisconsin, which conducts a number of meteorological studies for NWSC, is looking at several possible probes for meteorological satellites. One proposal is that 8-10 nonscanning infrared detectors using small reflective optics could provide broadband or window radiation data with 100-mi. resolution.

This "bug-eyes" or "broom" array would obtain information in a simple format easily prepared for immediate use. Prototype sensors will be developed.

● **Testing**—The satellite center also is developing its own capability to conduct physical measurements and tests of instruments and materials related to satellite observations. Photometric standards compatible with National Bureau of Standards measurements are being developed. In addition, an artificial Sun source for calibrating satellite TV cameras has been developed.

The Weather Bureau's research effort is by no means accomplished when the satellites are in orbit. Meteorologists are looking to the day they can derive quantitive information from satellite data for input into synoptic analyses and to numerical weather prediction models.

● **Cloud picture data**—A team of researchers at the NWSC is making experiments using satellite data to modify the analysis of the initial flow field on which numerical weather prediction is based. These modified analyses have been compared with those derived from nonsatellite data with encouraging results.

Small but significant improvements have been achieved in cases where substantial errors previously existed. Weather Bureau officials say. However, some errors still exist. Two studies are going on in this field: one to see to what extent clouds correspond to the concurrent vertical motion field, the other to determine the best method of incorporating a given vertical motion field into the parameters used in the numerical computer models.

Case studies are now under way to test the diagnostic computer programs that have been developed. This work is expected to lead to a more complete understanding of the cloud patterns associated with weather systems. By getting an hour-by-hour history of the three-dimensional motion of the air parcels from routine data, researchers

then have a means to compare what has happened during the 12 hours between satellite passes over one point.

The airlines have participated in studies of the satellite data also, with especial interest in the conditions that produce clear-air turbulence. Four cloud-pattern models are being used for studies aimed at more accurate location of the jet stream.

● **Hurricanes**—Correlations between *Tiros* hurricane cloud pictures and the measured intensity of these storms has already produced usable results for operational application. Further refinements are being made.

A theoretical investigation is being conducted at the University of Chicago on the formation of hurricanes. Satellite data is expected to provide data on the spatial distribution of moisture in hurricanes, which may help in identifying its causes.

Aircraft and rocket support of satellite work will continue, to maintain verification of the low-resolution TV pictures and infrared data.

The Weather Bureau also has several contracts out to develop interpretive cloud-picture catalogs so that future pictures con be recognized quickly both by research meteorologists and operational forecasters.

● **Radiation data**—Usability of the data has been complicated by the problems of calibrating the instruments just before launch, and the changes or degradation that occurs after launch with no means of recalibration. Other complications are caused by the mode of operation of these instruments themselves, since measurement of radiation intensity made at a particular angle must be used to estimate the upward flux of radiation integrated over all angles.

Studies are being made on the differences between radiation values over the same regions for overlapping orbits both a few hours apart and for 12 hours apart. These will help in checking reliability of the data, diurnal variability of the radiation fields, and use of the satellite data.

Satellite measurements of reflected solar radiation also will be compared with pyrheliometric measurements made from airplanes and from the ground. Weather Bureau scientists are seeking to develop a method to compute the solar energy absorbed directly in the atmosphere. Future, more accurate measurements than those made by earlier *Tiros* satellites may make it possible to compute the amount of solar energy reaching a horizontal surface on the ground in areas where surface measurements cannot be obtained, Weather Bureau scientists say.

Other studies are under way to see to what extent significant cloud pattern features in large-scale cyclonic vortices

new rocket motor quartz piezoelectric pressure transducer



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Technically advanced in concept and design, the Model 616 transducer contains a nearly flush mounted miniature quartz pressure sensing element of very high resonant frequency (120,000 cps). This is protected from the severe combustion environment by a ceramic coated, liquid cooled flame shield. Effective cooling is ensured by large coolant passages, very high source pressure, and high velocity coolant flow through the shield.

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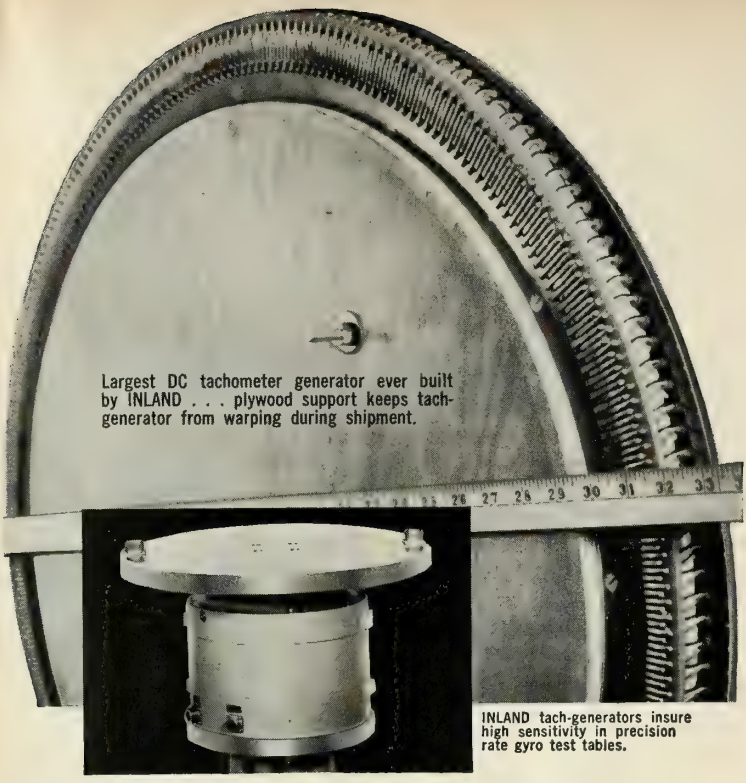
Model 616 is furnished with a standard ½-20 mounting thread. Available modifications include liquid cooled probe and helium bleed features.

Write for Bulletin 194964. Kistler Instrument Corporation, 8973 Sheridan Drive, Clarence, N.Y. 14031. Representatives in principal cities.

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can be distinguished by satellite infrared observations. Other studies to relate satellite radiation measurements to parameters of importance for analysis and prediction of weather will continue.

Research also will continue on the Earth-atmosphere heat budget and response of the atmosphere to variations in this energy. Machine computations are made of a number of atmospheric energy parameters for one synoptic time each day in the 850- to 500-mb layer, to compare with satellite data. These parameters include available potential energy, kinetic energy, and various energy conversion terms.

This kind of work holds special interest because energy variations over the past several winters have had wide differences. Several winters have had energy cycles with large amplitudes and strong heat transport. Others have had weak cycles, and low heat transport.

Other energy studies will eventually be combined to aid in understanding the significance of various scales of differential heating of the atmosphere in the production of kinetic energy.

● **Digitized cloud pictures**—During the TOS lifetime and through advanced programs, the National Weather Satellite Center plans to use a technique of converting analog picture data to digitized input to the large-scale computer.

According to the Weather Bureau, information in this format will be most useful to the general meteorological community. With the computer programs now under development, utilization of the data could be achieved "well beyond that possible with human resources alone."

Thus, picture descriptors such as percent cloud cover, average cloud brightness and a pattern indicator are translated into a numeric square-grid representation. At first, meteorologists did not seem to be satisfied with this simple representation—even though it provided the desired interpretive information. This is partly due to the fact that the continuous gray scale of the photographs permits the viewer to focus on interesting features.

For this reason, the Weather Bureau has put a great deal of effort into devising numeric characters with set gray scale appearances. For instance, the scale begins with an all-white square, a light numeral "one," a little more shaded "two," and so forth, until nine and 0 are very dark, leading to an all-black square. Thus the resultant product still resembles the cloud-cover photos.

Several other visual output display devices also are aimed at providing this kind of gray-scale recognizability, some of which will be used for high-quality, permanent recording as well. ■

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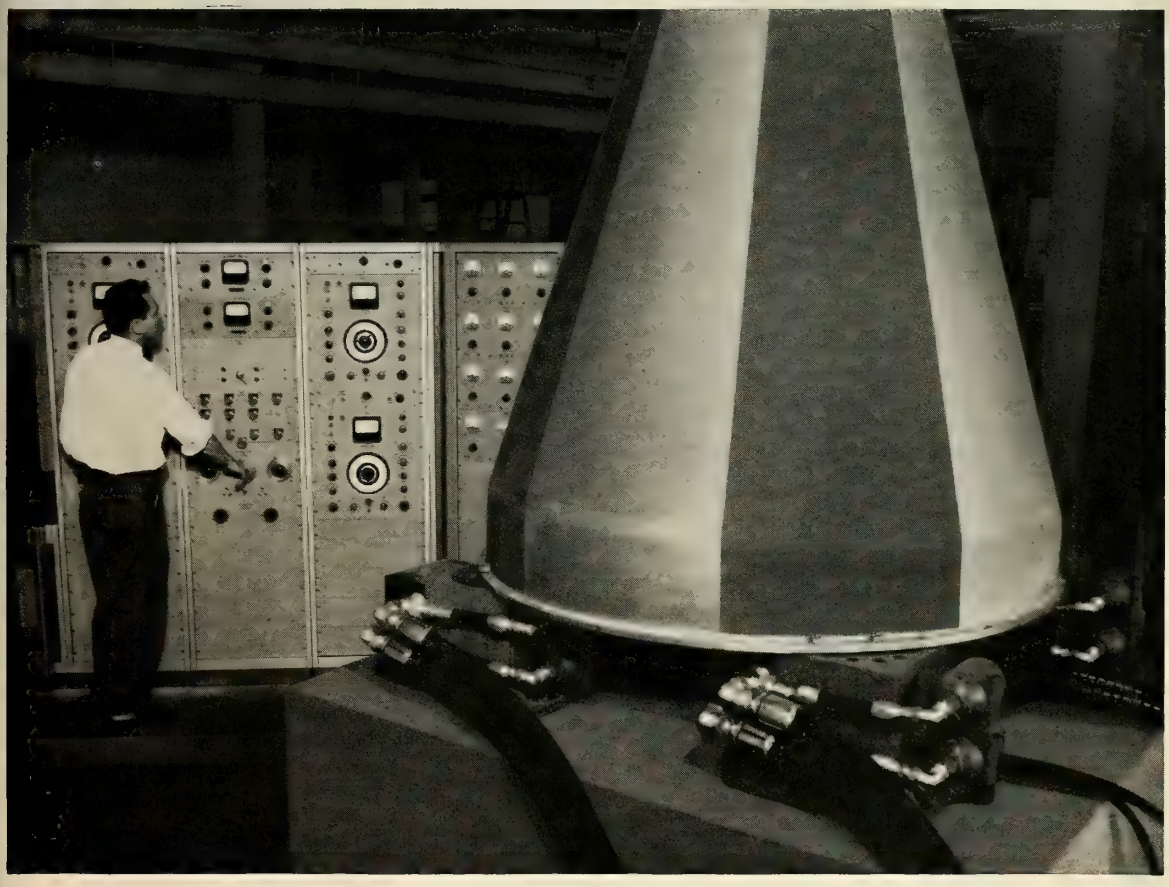
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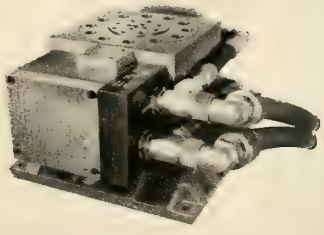
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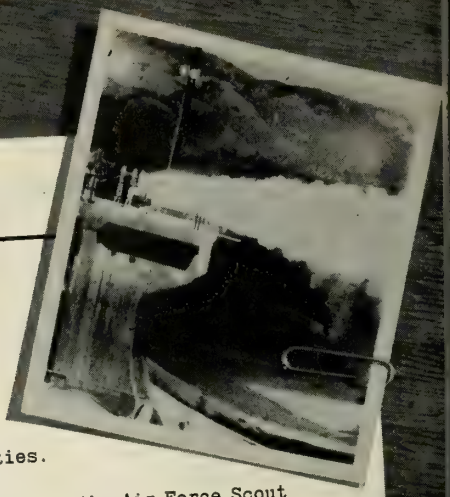
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Out of these facilities have come developments which are a significant indication of UTC's present capabilities.

Solid Propellant Rockets.

1. Is developing a new and 50% more powerful fourth-stage for the Air Force Scout space launch vehicle.
2. Developed, for the Air Force, the separation rockets for the Titan II and Titan III-C.
3. Is developing for the Air Force a segmented, 120-inch diameter solid propellant rocket motor. Two of these will be used as the booster stage of the Titan III-C. Clustering of these motors, which can be mass-produced in present UTC facilities, will make it possible to assemble boosters capable of producing as much as 20 million pounds of thrust without extensive development programs or facilities expansion.

Liquid Propellant Rockets.

1. Has extensively researched an entire family of liquid rocket motors--ranging from 1000 to 50,000 pounds of thrusts--for upper stage applications and armament applications.
2. In a series of altitude demonstration tests conducted by the Air Force at its facilities, a UTC liquid engine demonstrated the highest performance in its class to date. In a more recent Air Force test, conducted during an evaluation of a back-up program for the Titan III transtage--a UTC liquid engine demonstrated increased efficiency which would allow a 50% increase in payload.

Hybrid Rockets.

1. Built and test-fired, for the Advanced Research Projects Agency, the highest performance hybrid rocket engine yet developed.
2. Will develop, for NASA, a hybrid hover engine--the first to be considered for a space application--and a hybrid system twice as powerful as any yet fired.

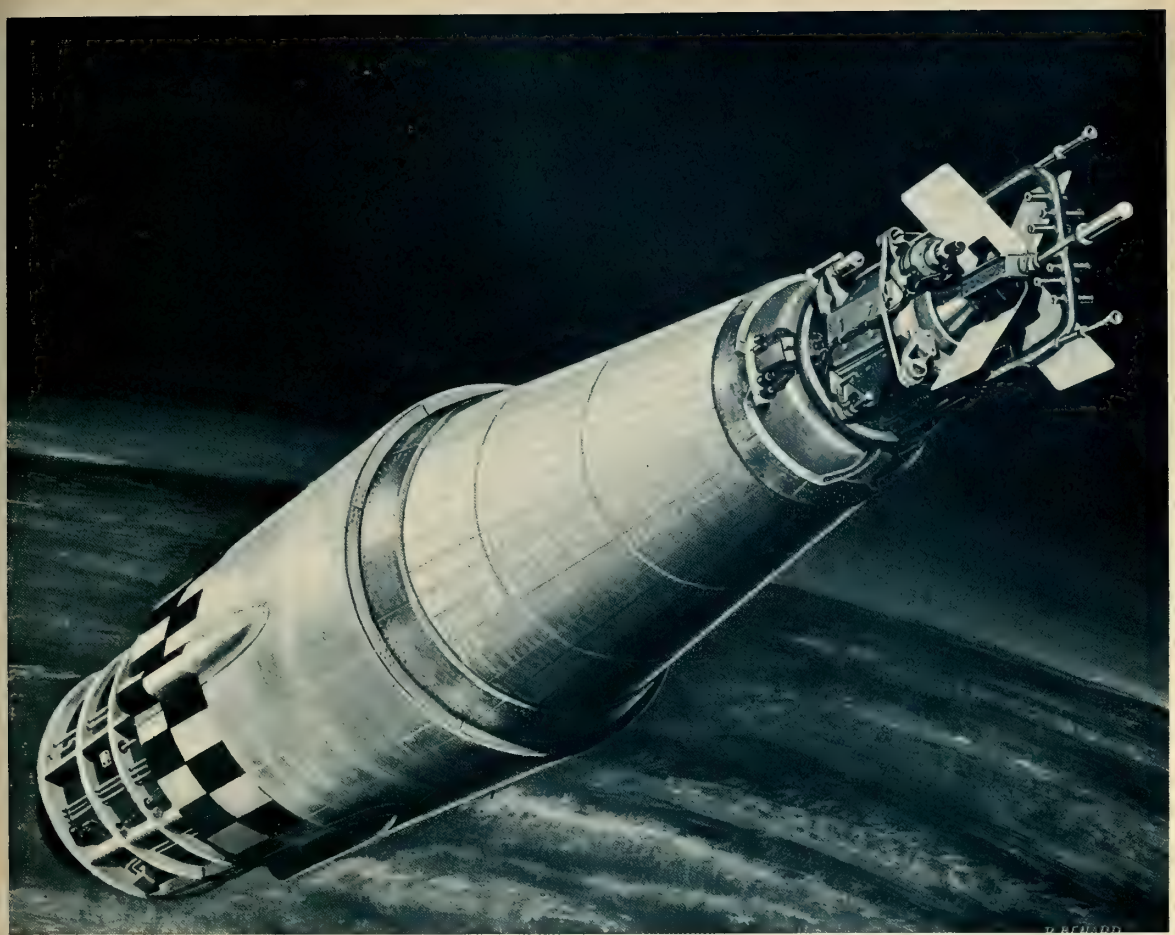
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3. Is the only manufacturer known to be capable of beginning immediate production of segmented glass fiber rocket casings.

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2. Has proven experience in the development of flight control systems, instrumentation systems, electrical systems, structures and AGE checkout equipment.

Further reference: write UTC, Sunnyvale, California



FLIGHT VERSION of SNAP-10A, first flight of which is planned early next year.

Part V

SPECIAL REPORT: ATOMIC ENERGY COMMISSION

AEC Likely to Spend Over $2 Billion On Rockets and Auxiliary Power Units

Total for decade could top $2.5 billion if step-up occurs in rocket development, SNAP-50/SPUR program; enthused SNPO manager outlines test timetable; a summary of activity

THE ATOMIC ENERGY Commission can be expected to spend well over $2 billion during the next decade to provide a nuclear-rocket capability and the nuclear auxiliary power units needed for long-lived satellites and deep space probes during this time period.

Current spending levels, if continued, will readily meet this estimate. An acceleration in the nuclear-rocket development effort and in the SNAP-50/SPUR Advanced Space Power System—a not improbable circumstance as the need for each becomes more apparent and more urgent—could raise total 10-year expenditures to over $2.5 billion.

The Space Nuclear Propulsion Program, a joint AEC/NASA effort, is directed by Dr. Harold B. Finger. The Systems for Nuclear Auxiliary Power (SNAP) Program is directed by Dr. Richard L. Kirk. Both were interviewed by MISSILES AND ROCKETS during the past few weeks. Their comments and those of many other government and industry officials are summarized below to indicate the present and future of both nuclear development efforts.

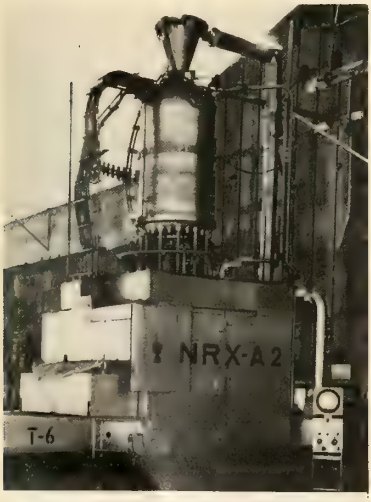
NUCLEAR PROPULSION

ABOUT A BILLION dollars would be needed to launch a nuclear rocket into a flight-test orbit by 1975, a feat that could be the precursor of manned exploration of interplanetary space by 1980.

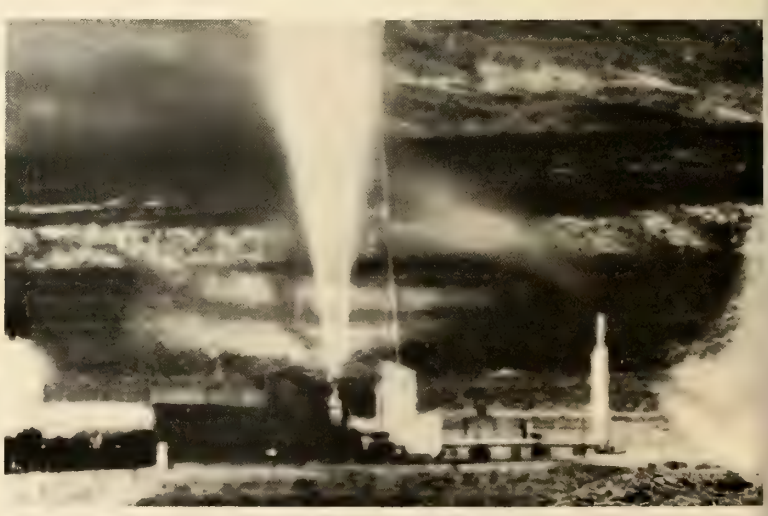
If a manned Mars expedition is attempted, NASA and AEC officials say, there is little doubt that the nuclear rocket will be used to propel the spacecraft between Earth and Mars orbits.

The nuclear rocket, with its proven specific impulse of over 700 seconds in recent static firings, appears to hold so much promise for space exploration, and is such a large step forward in rocketry, that Harold B. Finger, manager of the joint AEC-NASA Space Nuclear Propulsion Office (SNPO), regards the recent tests as equal in importance to the early liquid-fueled rocket experiments of Robert H. Goddard in the 1920's.

In discussing funding trends, Finger did not seem disturbed that the Fiscal Year 1966 budget for the nuclear rocket



FIRST NERVA reactor to be tested at power in Rover program at Test Cell "A," Nuclear Rocket Development Station, Nev.



NRX-A2 SENDS UP a plume of hydrogen over the Nevada desert during its successful power test of Sept. 24. High success of recent hot firings has encouraged nuclear-rocket proponents to press for post-Apollo space missions.

probably will not be greater than the $150 million in his current budget. He said that with level funding, important and needed things can still be done:

—Reactor technology can be further developed. Operations near the performance limits of reactors can be studied, for example.

—Engine system data can be obtained. For instance, the reactor can be hooked up to its turbopump, full controls can be installed, and a breadboard nuclear rocket could be run as a self-contained unit. This might uncover system problems that did not appear during component tests or paper studies.

—More work, including testing, can be done on the advanced reactor *Phoebus I*. The budget would also make it possible to start work on the high-power *Phoebus II* reactor, and to procure some hardware.

● **Background**—Project *Rover* is a joint AEC-NASA program to develop nuclear rocket technology for space exploration. Because of the cancellation last year of the portion of the program known as RIFT (Reactor In Flight Test), the main continuing emphasis has been on developing graphite-core reactors. During the past few months, SNPO, which runs the program, has scored spectacular successes during several static firings of experimental reactors.

Under its first experimental reactor program, known as Kiwi, the AEC's Los Alamos Scientific Laboratory (LASL) conducted an extensive series of hydrogen-cooled reactor tests to get information for the design of *NERVA* (*Nuclear Engine for Rocket Vehicle Application*). By absorbing reactor heat, hydrogen can be exhausted at high speed through a convergent-divergent nozzle, thereby furnishing thrust to the assembly.

The *NERVA* engine system, which is in the 50,000-lb.-thrust class, is to be used as the technological base for developing higher-powered reactor designs such as *Phoebus I* and *Phoebus II* (the latter also known as the advanced *Phoebus*).

Almost all the work going on at LASL is on *Phoebus I*, which is the interim test reactor of Kiwi size to provide data for the 5,000-mw., 250,000-lb.-thrust *Phoebus II*. *Phoebus I* will be run at higher power, temperature and for longer durations than any of the Kiwis; testing is scheduled for the 1965-66 period.

The industrial team of Aerojet-General Corp. and Westinghouse Electric Corp., under contract to LASL since 1961 for *NERVA* development, conducted the first power test of a *NERVA* Experimental Reactor—the NRX-A3—this past September. The reactor was built by Westinghouse's Astronuclear Laboratory. The reactor performed perfectly, running for six minutes—the limit of available hydrogen—and reaching 85% of full power. A month later the reactor was restarted and operated at low power for 20 minutes.

The harbinger of the *NERVA* tests was the hot run of the Kiwi-B4E reactor in August. In the first successful "live" run of a nuclear rocket reactor, the Kiwi performed for more than eight minutes at full power and temperature, and stopped only for lack of hydrogen. In September, the reactor demonstrated it could be restarted.

These reactor tests verified the fact that nuclear rockets could achieve the performance predicted for them, run a long time, be restarted and be built within today's state of the art. The full-power Kiwi-B4E test, for instance, developed a specific impulse corrected for altitude of higher than 750 seconds, as compared with 300-450 seconds for chemical rockets. The Kiwi thrust was 50,000 lbs., but this is not the fundamental parameter since it can be easily raised. Thus, AEC and NASA officials are confident they are now ready to fashion their reactors for major space missions.

● **Schedules and costs**—Finger laid out for M/R the following timetable for feasible nuclear propulsion development:

—*Phoebus II* reactor testing, 1967.

—Flight-test of *NERVA I* system, first half of 1970's; with stages using *NERVA I*, operational by 1975.

—Stages powered by *NERVA II*, based on *Phoebus II*, late 1970's.

—Mars nuclear-propulsion capability, late 1970's.

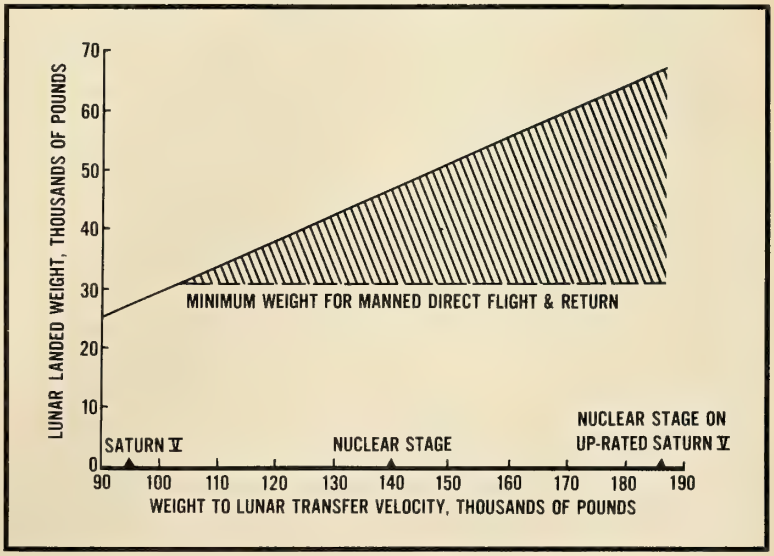
He stressed that this work could not be done without an increase in budget. He particularly would need ground facilities, which would have to be designed and built. He admitted that some of the design work is already under way in the expectation of mission work for the advanced *Phoebus*.

It will take about a billion dollars in as-yet-unappropriated funds to pay for a program culminating in the flight test of a vehicle based on *NERVA*. This amount includes the cost of the flight-test program itself as well as of the booster, pegged at about $100 million.

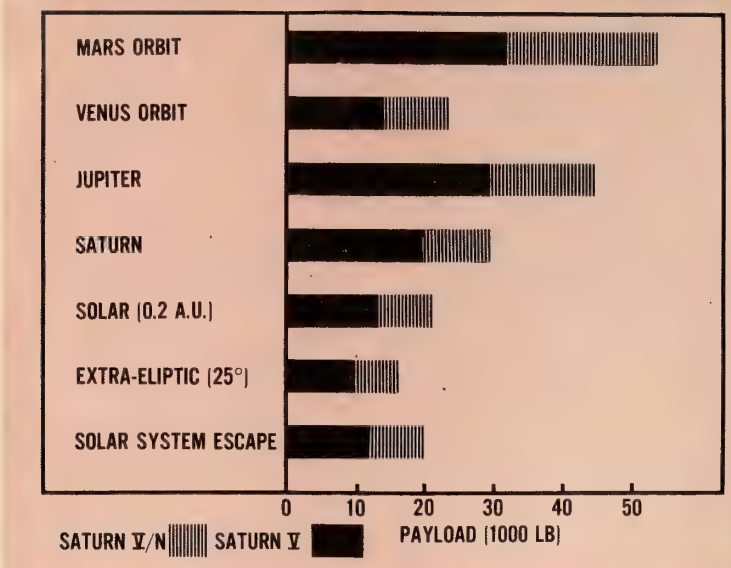
The total cost of Project *Rover* so far, including total monies from NASA, the AEC and a small amount from the Air Force several years ago, is $582 million through Fiscal 1964. NASA and AEC in Fiscal 1965 are spending $150 million. Thus, the entire project will cost nearly $2 billion, allowing for normal growth of early cost estimates.

In the nine years the *Rover* program has existed, the AEC has met nearly half of its expenditures, for a total of $283 million, with 73% incurred in the last three fiscal years. Biggest jump from Fiscal 1963 to Fiscal 1964 was in *NERVA*, from $29 million to $51 million. A lesser, but significant, jump occurred in advanced technology, where expenditures rose from $6.6 million in Fiscal 1963 to over $11 million in Fiscal 1964. Not unexpectedly, in view of the amount of money already spent on Kiwi development, this pioneering reactor program dropped in expenditures from $25 million in Fiscal 1963 to $22.6 million in Fiscal 1964.

● **Post-Apollo missions**—The work SNPO is doing is scaled to the missions



EFFECT OF NUCLEAR third stage on lunar-landed payloads.



INTERPLANETARY MISSION summary for Saturn V with third stage either chemical (solid block) or nuclear (shaded area) and fourth stage cryogenic.

after *Apollo*. Thus, the nuclear rocket effort is not stymied by lack of a requirement but can go along with technology development. Working at this lower level of effort, SNPO finds that, while the scope and magnitude of the nuclear rocket program may be affected, its existence is not.

A *NERVA* stage, with its 50,000 lbs. of thrust, put in as the third stage of a *Saturn V* booster, could far exceed the utility of an all-chemical *Saturn V* for some lunar and all interplanetary missions. In fact, manned interplanetary exploration is one of the chief potential missions for the nuclear rocket.

Studies show that a nuclear third stage such as *NERVA* on a *Saturn V* could land about 47,000 lbs. of payload on the lunar surface by means of a direct flight from Earth. This would provide about a 30-day dwell period on the Moon for four astronauts. The all-chemical *Saturn V* could not be considered for such a mission, since it could lunar-land on a direct flight from Earth only about 27,000 lbs.; the minimum lunar-landed weight needed for a manned direct flight and return is about 30,000 lbs.

Beyond *Apollo*, an uprated *Saturn V* with a *NERVA* stage could carry 70,000 lbs. to the lunar surface, thereby increasing the astronauts' stay time to more than 90 days. Clearly, the nuclear stage would also find use as a lunar logistics vehicle, performing far more cheaply and reliably than all-chemical systems.

By the same token, *Saturn V* would also become more useful and its operating life would be extended beyond *Apollo*. Even well beyond *Apollo*, there would be no need to develop nuclear rockets able to fly from Earth to orbit "because the chemical booster technology is already at hand and would be difficult to improve upon," according to Finger.

Manned interplanetary missions such as to Mars call for about two million pounds of spacecraft and payload weight in Earth orbit. Estimates as low as one million pounds and as high as three million pounds have been given for this same mission. Regardless, if all-chemical propulsion were to be used for the Earth-orbit-to-Mars and back-to-Earth-orbit trajectories, the weight in Earth orbit would be between three and five times that needed for an all-nuclear vehicle.

The *Phoebus II* could be used for propulsion for all interplanetary missions through the Mars mission. For the manned Mars mission, two or three *Phoebus II's* would be clustered in the first stage used to depart from Earth orbit, a *NERVA II* would be used in the second stage, and either a *NERVA II* or *NERVA I* in the third stage, depending on payload requirements.

The manned Mars mission would have to use boosters beyond the *Saturn V's*, seven of which would be needed to put two million pounds in Earth orbit.

● **Clusters feasible**—One question unknown that must be resolved, before modules of nuclear powerplants are strung together in orbit like parts in a Mechano set, is the effect of clustering on high-power reactors. Would there be a leakage of fission neutrons from one unshielded reactor to the next, for instance, thereby causing instabilities?

Recent low-power tests at LASL this fall indicated that what little interaction did occur could be easily controlled. During the work, in which criticality was introduced into two adjacent reactors during the running period, the units were gradually brought closer together until only one foot separated their aluminum pressure shells. At this point, the power produced at the outer periphery of each of the cores changed by about 5%. On the strength of these tests, and the knowledge that this interaction phenomenon is stable and easily controllable, LASL scientists predicted, according to *Missile/Space Daily*, that multimillion-pound-thrust nuclear propulsion systems could be constructed by clustering "two, three, or as many (nuclear rocket engines) as physical size permits."

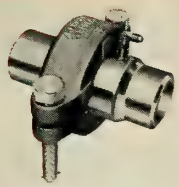
Yet the power level of the reactors used in the test were held below one kilowatt, even though their nominal ratings were 1,000 megawatts each. Although the higher powers and temperatures could introduce manifestly different coupling effects, LASL scientists believe that the problems raised would still be relatively small and not apt to cause instabilities.

● **Tests scheduled**—Although not part of the Kiwi development program, safety tests of Kiwi will be started next year. Called Kiwi TNT, for Transient Nuclear Test, these experiments will determine whether anything drastic happens when the control drums are rotated rapidly, thereby cyclicly building up and cutting down reactor power. High temperatures and rapid structural changes in strain are expected, but nothing of an explosive nature.

Next fall at LASL, the *NERVA* reactor will be tested in a system configuration, about a year ahead of schedule. The engine-reactor assembly will be tested with nozzle pointed downward rather than upward as in the tests up to now. This will be the first self-contained hot test of any nuclear rocket and will be the next high point in this country's development of the nuclear engine.

● **Facilities**—No major new facilities are planned for Fiscal 1966. Only about $3 million is expected to be spent to improve old facilities for *Rover;* this includes installation of water lines in one of the test sites and some small structural changes in physical plant.

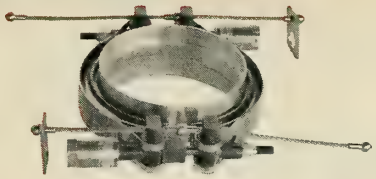
When the RIFT program was alive, the SNPO had requested four additional test stands. Each costs about $20 million



Double-Seal Pipe Joint with buffer zone outlet



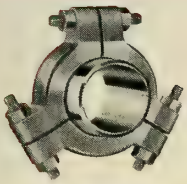
Single-Seal or Double-Seal Bolted Tube or Pipe Joints



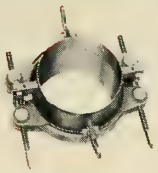
Tube Joint with explosive latch device



Double-Seal Pipe Joint with remote handling devices



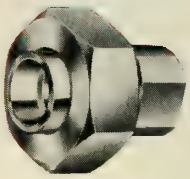
Standard Pipe Joint with V-Retainer segments



Tube Joint with remote handling devices



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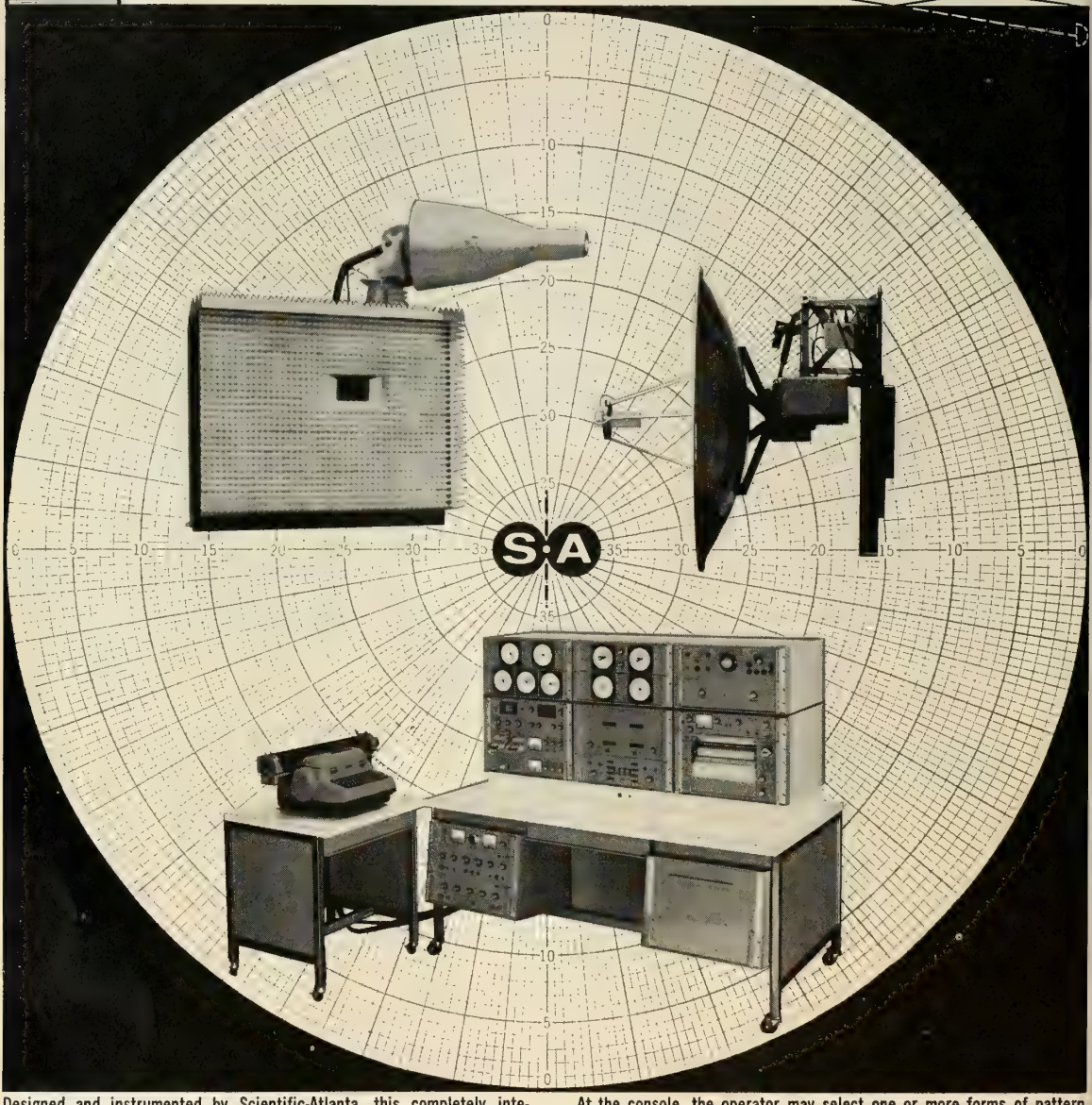
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and takes three to four years to design and build. There is little doubt that if a flight vehicle program is re-instituted, these stands will be built. At present, SNPO has only its Test Stand No. 1, although planning has started for the design of a combined engine-and-stage test stand.

Since nuclear reactors are putting such a severe strain on the components of test facilities, and calling for a high degree of similarity to actual operating conditions, many test items are wanted. But the present economy mood of the Administration, and the uncertain future of the nuclear rocket, make SNPO officials reluctant to draw up a complete shopping list.

Some items, nevertheless, will be required shortly. Finger is calling for an effective system to pull away the rocket's exhaust during a static firing. In addition, he sees a need for a flame deflector for *Phoebus* tests that can handle the hot hydrogen exhaust at about 3,500°F.

Also not yet available but highly desirable is equipment for re-assembling a hot engine by remote control. Unfortunately, only disassembly is possible today.

● **Technical problems**—Developing a nozzle able to withstand the severe environment introduced by hot, radiating hydrogen probably will be causing difficult engineering problems for nuclear-rocket designers for many years. Current SNPO efforts include:

—Trying to learn more about the way heat flows from the exiting hot-hydrogen propellant to the nozzle walls; this information would be used to estimate the temperatures and stresses in the nozzle coolant tubes.

—Looking into alternate designs and materials to get the best combination for nuclear-rocket performance.

—Determining fabrication and quality control techniques to be sure the final product will be able to stand up under operating conditions. This area is pinpointed as the one causing major problems; part of the problem is the difficulty of simulating the operational environment.

● **Control system**—The engine-control system for *NERVA* has not yet been fixed. The main problem is to design the hydrogen-flow loop and the reactor power loop so that the entire system operates stably and provides the performance needed. Stable operation includes reactor start-up and shut-down transients as well as the steady-state condition. Another burden is the need to keep the reactor operating stably even though a component in the system may be degraded or inoperative.

Control sensor development is another key problem area, chiefly because the sensors must operate reliably in the reactor environment. "Our needs include a wide-range neutron flux measurement, a radiation-resistant pressure sensor, and a quickly responding measurement of the high-temperature reactor exhaust gas," an AEC official told an international meeting early this fall.

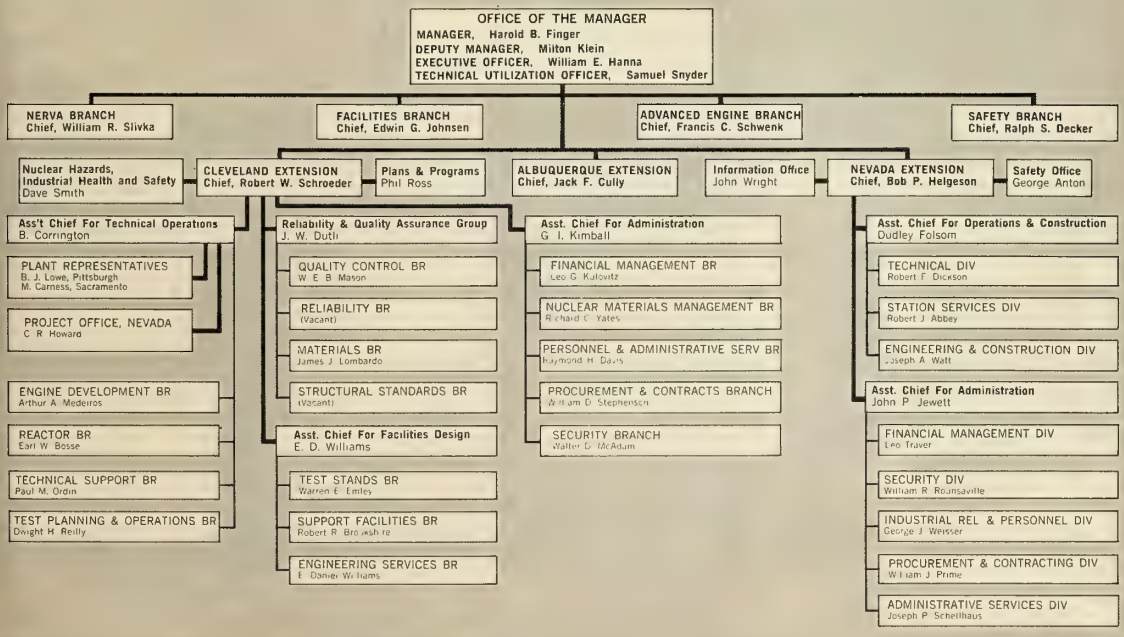
● **Radiation problems**—Because the nuclear rocket technology leans heavily on chemical rocket experience, particularly the hydrogen-oxygen rocket, only those problems peculiar to a nuclear rocket are getting extensive study and work. In particular, research is heavily oriented toward practical problems called forth by the radiation environment: pumping boiling hydrogen, operating high-speed bearings in a radiation field, and developing pneumatic radiation-resistant control circuits.

Two factors not met with in the Kiwi or *NERVA* work will come up during the higher-powered *Phoebus* experimentation.

The first is damage that might be done to structural materials by long-term radiation. Formerly, this could be ignored; now, when total radiation dosage may induce crystal structural disorders, some exotic and difficult problems arise. They become onerous when combined with high-temperature gradients introduced by the cryogenic hydrogen.

For this reason, the most important design factor in choosing materials may

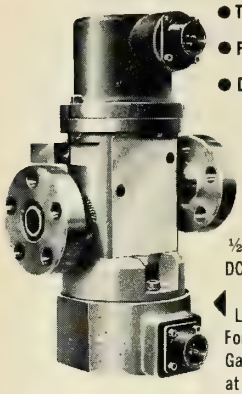
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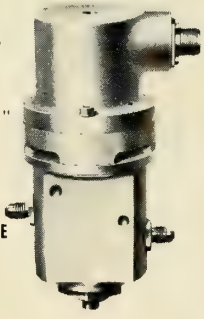


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be their ability to withstand the radiation environment.

The second factor, which actually is an outgrowth of the first, is the effect of the concentrated radiation doses introduced by a cluster of nuclear engines. For low power it has been shown there is no problem, and it is hypothesized that for Kiwi- and *NERVA*-size reactors, it will be no problem; for *Phoebus* and beyond, however, there will be significantly increased dosages to control systems and feed-system components due to neutrons and gamma rays which emanate from the sides of adjacent engines. Even so, the SNPO does not anticipate any unusual effects in clustered nuclear engines "which might inhibit their use in space missions." To make sure of this, the office is sponsoring studies of the effects of high radiation doses on some components and materials.

In addition, SNPO has made substantial investments in test facilities capable of testing materials and components of the nuclear rocket in closely simulated radiation environments.

On a time scale beyond the solid-core nuclear rocket for propelling spacecraft, and even beyond electric propulsion, Finger sees advanced concepts such as the gaseous-core reactor for heating hydrogen, pulse propulsion systems and the *Orion* concept. Still further into the future, he says, "there are controlled thermonuclear fusion possibilities (but these are) quite remote."

SNAP DEVELOPMENT

AT THE REQUEST of the Dept. of Defense in 1955, the Atomic Energy Commission initiated a broad program to develop compact, long-lived electrical power generators using radioisotopic fuels, and later (1959), reactors for thermal conversion. The effort soon became known as the Systems for Nuclear Auxiliary Power, or SNAP, program.

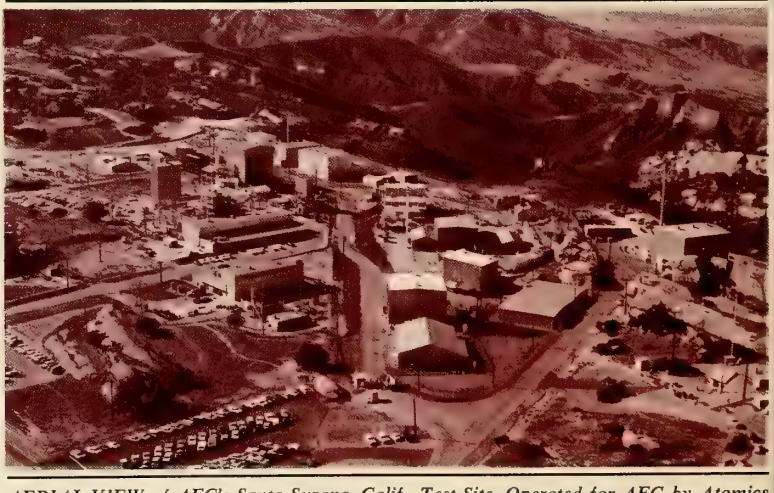
In 1963, DOD withdrew its requirement for such systems, but thanks to the persistence of the Joint Atomic Energy Committee in Congress and the confidence of the AEC development team, the program has been preserved.

A major fact of life in the development of such units is the long lead-time required—eight years as compared with the four to five years currently required to develop a space system or vehicle. Possible applications have always been envisioned, but the problem has been to pin users down to specific requirements. The AEC approach, then, has been to lay a broad enough foundation in its R&D effort to provide the technology and the test data when needed.

Funding levels, however, have been held down; this has slowed systems development. Also, due to the nature of the origin of the two SNAP unit programs, the industrial capability or depth has been restricted. Essentially, three contractors have been responsible for the bulk of the R&D programs. The AEC is now attempting to broaden this base.

- **Funding in FY '65**—(See accompanying table). AEC SNAP programs break conveniently into three parts: reactor-type generators, radioisotope power sources, and SNAP-50/SPUR (Space Power Unit Reactor) advanced space power and electric-propulsion system. (Note—reactor units employ even-number SNAP designations, radioisotopic systems use the odd numbers.)

Funding for these programs has been increased for FY '65 and is expected to increase again in FY '66. New



AERIAL VIEW of AEC's Santa Suzana, Calif., Test Site. Operated for AEC by Atomics International Division of North American Aviation, Inc., the station is employed in SNAP-reactor development, fabrication and testing.

applications, particularly in space, are expected for the radioisotope systems; reactor development will require ground test systems to broaden the technology; and if SNAP-50 is to be available in a practical time frame, its program development must be accelerated.

In the FY '65 budget, about $13 million is for facilities—$4.2 million for their equipment and $8.8 million for construction. Of the latter, $6.2 million will be used to support SNAP-8 flight prototype testing and $1.8 million to build a boiler test facility at Connecticut Advanced Nuclear Engineering Laboratories (CANEL) for SNAP-50 subsystem testing.

Two major SNAP-50 facilities will be needed to continue the program—one for nuclear system tests and one for non-nuclear. Under the present schedule, reactor testing is due to begin in 1969; the first integrated system tests are set for the 1972-73 time period to meet a probable system operational need by 1977.

RADIOISOTOPE GENERATORS

A LONG-TERM developmental program for advanced thermoelectric and thermionic heat-to-electricity conversion systems employing radioisotope heat sources was begun in March, 1956, with selection by AEC of the Nuclear Div. of the Martin Co., Baltimore, as prime contractor.

The underlying aim of the effort is to develop a family of systems capable of producing different power levels for use in both space and Earth electrical-power applications.

● **SNAP-3**—The first complete thermoelectric generator developed under the program was SNAP-3, which was built by Martin using a thermocouple unit produced by Minnesota Mining and Manufacturing Co. (now 3M Co.). Completed in December, 1958, the power unit was fueled with Polonium-210 capsules produced at the AEC's Mound Laboratory in Miamisburg, Ohio. This particular radioisotope, which is an alpha emitter, was selected because it fit the need and was readily available.

Martin completed the assembly, tested it and delivered it to the AEC in January, 1959. Considered a proof-of-principle unit, the 4-lb. prototype produced 2.5 watts total power using a half charge of Po-210.

Later, to adapt the generator for test use as an auxiliary power unit in the Navy's *Transit* navigational satellite, five pounds of Plutonium-238 was introduced as the fuel because of its longer half-life characteristic—nearly 90 years instead of less than 5 months. On June, 1961, the first nuclear-powered satellite was placed in orbit—actually the SNAP-3 system was used to supplement, not supplant, the *Transit 4A's* solar-cell

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power system. A second vehicle, *Transit 4D,* carrying another SNAP-3 power source was orbited on Nov. 15, 1961. The first system is still performing satisfactorily; the second failed after eight months.

• **SNAP-1A**—A 125-watt R/I-fueled generator, called SNAP-1A, was developed by Martin concurrently with SNAP-3, for space applications. Fueled with Cerium-144, the system weighed 200 lbs. and was designed for a minimum one-year operation. Employing a static thermoelectric power conversion system, overall system efficiency was on the order of 5%.

For ground-handling operations prior to launch, the system required use of a 4,000-lb. mercury shield (removable) for radiation protection. (The radiation level, 100 ft. from the bare core, was 22 Roentgens/hour.)

The Air Force requirement for the system was cancelled in 1960 while the system was still in the hardware development phase. It was never flight-tested.

• **SNAP-9A**—An advanced version of the SNAP-3 was next developed to provide power in an operational military navigation satellite. Producing 25 watts and also using Pu-238 for fuel, the 27-lb. system, named SNAP-9A, was orbited in a *Transit* satellite on Sept. 18, 1963, and is still performing satisfactorily. Another was orbited in December, 1963.

• **SNAP-11**—For NASA's *Surveyor,* the unmanned lunar-surface exploration vehicle, SNAP-11 is currently under development. To be fueled with Curium-242, the 30-lb. power generator will produce a minimum of 18.6 watts and operate continuously throughout the planned 90-day mission. The system now in test is expected to be ready for delivery to NASA next year. An electrically heated generator was delivered by Martin to the Jet Propulsion Laboratory last May for testing.

• **SNAP-19**—Originally conceived for NASA's *Interplanetary Monitoring Probe (IMP)* series and later redirected toward the *Nimbus-B* experimental meteorological satellite, SNAP-10 development is now under way. A thermoelectric generator employing Pu-238, its design will be simple and require less weight than SNAP-9A, but still produce 20 watts total power.

Six prototype generators will be built by Martin under the present contract. Two 18-lb. generators will be carried in each satellite and the combined systems will have a five-year designed operating life.

The system eventually may be employed in the Weather Bureau's *Advanced Tiros* operational meteorological satellite program.

• **SNAP-17**—Last November, General Electric and the Martin Co. were selected by AEC for first-phase development of SNAP-17, a 30-watt-output thermoelectric generator. Fuel for the proposed 30-lb. system will be the beta emitter Strontium-90; with the goal of producing a very long-lived (3-5 years) power device for a *Medium-Altitude Communication Satellite.*

• **SNAP-7 series**—For terrestrial applications, a family of SNAP-7's was initiated in 1960 and has since been developed—all units employing nearly the same basic design. Each uses Sr-90 as a fuel, but it is in the form of an insoluble compound, strontium titanate. Depleted uranium is used as a radiation shield with six of the seven exist-

SNAP EXPENDITURES FY 1962-65*

(Figures include expenditures for operation, facilities and equipment procurement, but exclude depreciation and cost of materials used.)

SYSTEMS	FY'62	FY'63	FY'64	FY'65	TOTAL
	(in millions of dollars)				
Reactor Power	39.5	50.0	47.7	62.6	199.8
Radioisotope Power	4.2	2.7	5.4	7.0	19.3
Advanced Space Power	16.9	37.2	23.0	23.1	100.2
TOTAL	60.6	89.9	76.1	92.7	319.3

*Authority: AEC's SNAP Program Office, Germantown, Md., Nov. 2, 1964



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ing units in the series—SNAP-7E is provided with a massive iron container which serves as both a shield and a pressure vessel.

● **SNAP-21 and -23**—As a follow-on to the SNAP-7 series, the AEC is pressing a development effort to cut costs and weight and, at the same time, improve efficiency and reliability in future radioisotope thermoelectric generators for a variety of terrestrial applications.

These include:

—SNAP-21, a 500-lb., 10-w unit for deep-sea employment providing up to a factor-of-10 weight reduction in the generator.

—SNAP-23, a 900-lb., 60-w device for a program concentrating on advancing thermoelectrics and system technology for land uses.

● **SNAP-15**—One-pound, one-milliwatt generators having a five-year design life are being developed for nuclear-weapon applications under a long-term program. The miniature units, which will use Pu-238 for fuel, will employ a very rugged design.

● **SNAP-13**—A demonstration device, to be designated SNAP-13, is now under development and employs thermionic conversion. Such systems offer the possibility of a significant increase in both power-to-weight ratios and conversion efficiencies.

The unit now in development is to be fueled with Curium-242 and will produce 12 watts output and weigh about 4 lbs. It will be capable of performing throughout a 90-day space mission.

● **Other SNAP projects**—Many R&D projects are under way to support SNAP development. Among the major ones:

—A test generator using Strontium-90 is being developed by RCA's Astro-Electronics Div. Using 60 thermocouple assemblies, the unit is designed for a 30-we output.

—General Instrument Corp. is developing a thermoelectric generator designed to use unrefined (mixed fission) fuel products as a heat source. The fuel is characterized by a very low power density compared to that available with refined fission products.

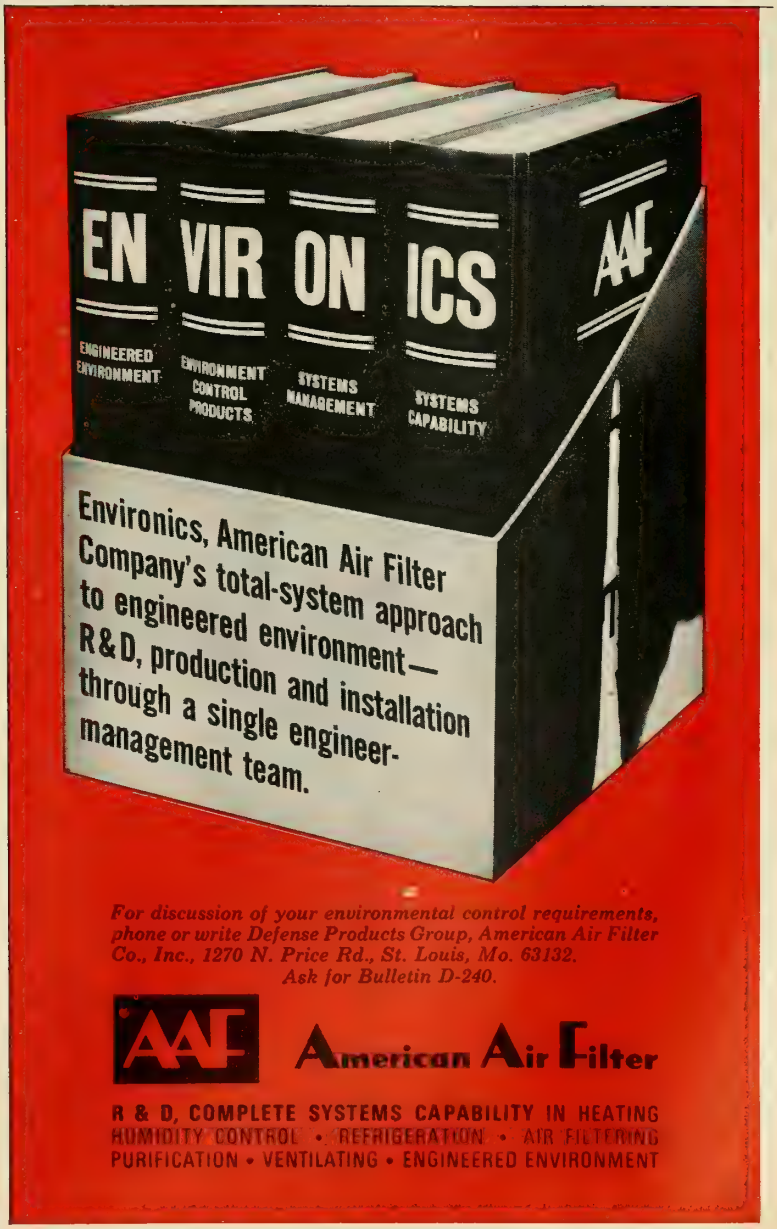
—Royal Research Corp. is working on a Cesium-137 fueled radioisotope generator. The heat source, built by Oak Ridge National Laboratories, employs cesium borosilicate glass, shielded with depleted uranium. Problems have been encountered in trying to successfully assemble the heat source and conversion unit, but the development effort is being continued.

—For the *Surveyor* Lunar Roving Vehicle, the AEC in May selected General Electric's Missile and Space Div. and RCA's Astro-Electronics Div. to design 40 to 50-w thermoelectric generators. The radioisotope systems, fueled with Plutonium-238, are to be designed for total weights under 30 lbs. and a one-year operating life.

—Two NASA study efforts that may well influence future development and use of SNAP units will be performed by Douglas Aircraft Corp. and Space-General Corp. Douglas will prepare a preliminary design for an integrated radio-

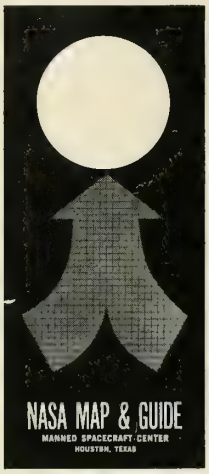
SNAP APPLICATIONS

SNAP Model	Power Output	Developed For	Weight (lbs.)	Application
7	10w	(AEC conceptual design)	———	Prototype
7A	10w	U.S. Coast Guard	1,870	Light buoy, Curtis Bay, Md.
7B	60w	U.S. Coast Guard	4,600	Lighthouse, Curtis Bay, Md.
7C	10w	U.S. Navy	1,870	Auto. Weather Stn., Antarctic
7D	60w	U.S. Navy	4,600	Unmanned Weather Boat, Gulf of Mexico
7E	7w	U.S. Navy	6,000	Experimental deep-sea navigational beacon, off Bermuda coast
7F	60w	AEC	———	Demonstration device and possible use with beacon for offshore oil drilling rigs



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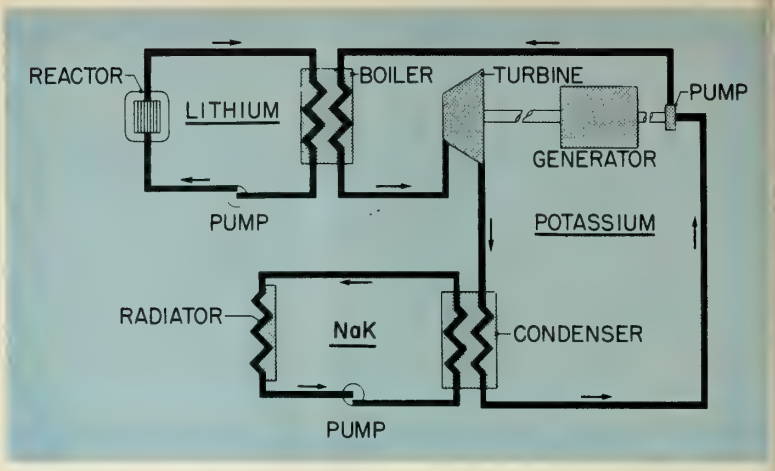
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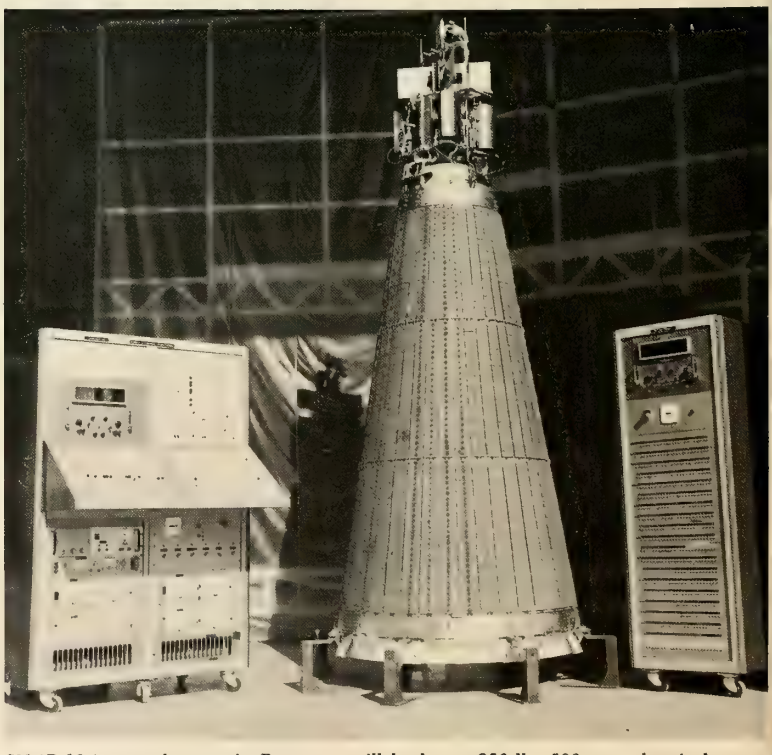
SCHEMATIC FLOW DIAGRAM of SNAP-50/SPUR flight system, showing reactor, turbine, generator, condenser and radiator arrangement.

isotope power supply for the *Manned Orbital Research Laboratory;* Space-General will study unmanned vehicle applications for SNAP units.

NUCLEAR-REACTOR POWER SOURCES

PARALLELING radioisotope power-generation efforts is a very broad development program for a family of small, lightweight, long-lived, nuclear-reactor electrical power sources. Believed both ideal and essential for future space missions, these units will provide reliable power throughout the 0.5-300 kw range.

Prime contractor for the AEC in the SNAP-reactor development program is Atomics International Division of North American Aviation, Inc., Canoga Park, Calif. The firm's responsibility



SNAP-10A ground test unit. Prototype will lead to a 950-lb., 500-watt electrical-output flight system for space auxiliary power.

includes power conversion systems and reactor development, together with some system testing—particularly of SNAP-8.

The program began in 1955 following a request to the AEC by DOD to look at the feasibility of reactor-type auxiliary power systems for possible military space applications.

● **SNAP-2**—The first system developed under the program was SNAP-2, using a small uranium-zirconium hydride reactor as a heat source. A joint AEC-Air Force effort initiated in 1956, it was designed for the 3-kwe range and used a mercury-Rankine cycle turboelectric power-conversion system. In 1963, DOD cancelled its requirement for the system. The program has been reoriented by AEC toward a component development program (see below).

● **SNAP-10 series**—Initiated at about the same time as SNAP-2 was the SNAP-10 system. An engineering design was completed in 1959 for a 300-we, 330-lb. conduction-cooled reactor system employing thermoelectric conversion.

In 1960, it was decided to raise the output to 500 we and adapt the SNAP-2 reactor in a convection-cooled flight system, designated SNAP-10A. Weighing about 950 lbs., including shielding, the unit is due to get its first flight test early in 1965.

Following a 90-day ground-test last January, using an electrically heated flight-system mockup (FSM-1) which produced a 500-w output continually under a simulated space environment, the first flight system (FS-1) went critical in April. A 90-day test using the FS-1 nuclear heat source in a simulated space environment was completed successfully this fall. Testing of subsystems will continue through early 1965.

● **SNAP-2/10A**—Both SNAP-2 and SNAP-10A generators can be upgraded from their respective output levels of 3 kwe and 0.5 kwe to 10 kwe and 2-3 kwe, according to AEC engineers.

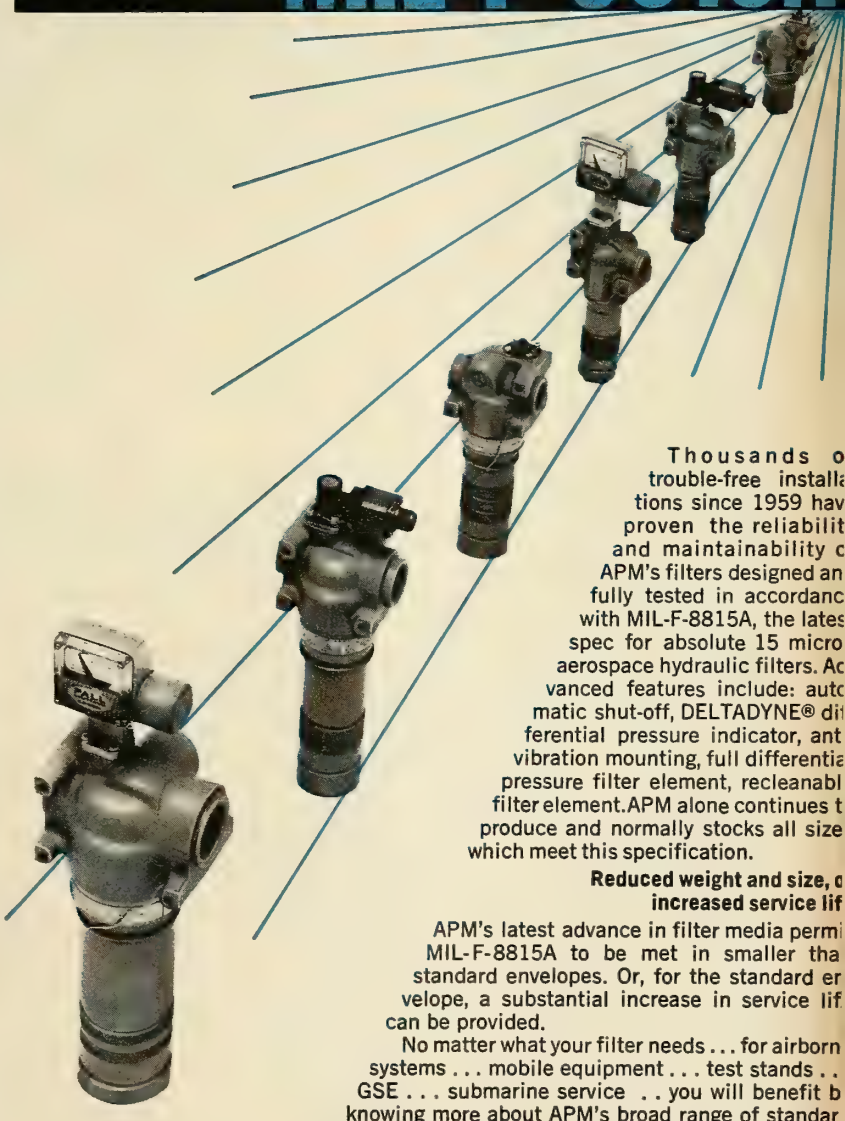
A major effort to advance technology with the two systems is the further development of dynamic turboelectric conversion systems. In advancing the mercury-Rankine cycle, two approaches have been taken:

—A high-speed, very compact unit for producing up to 5 kwe power output has been tested and is still in development.

—A lower-speed system under early development for NASA is capable of power outputs up to 35 kwe. This system, which requires considerable reactor advancement, has been designated SNAP-8.

SNAP-10B, a second-generation system, is now under advanced study. The principal goal is to determine how to significantly reduce reaction diame-

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ter size and the number and extent of external protrusions. The latter tend to scatter and reflect neutrons, thus increasing the radiation level at the payload. A new reactor will be designed with redesigned 10A reflectors.

● **SNAP-8**—In a joint AEC-NASA program initiated early in 1960, Atomics International is directing design and construction and will test the 35-kwe SNAP-8 space power unit.

Aerojet-General, under a separate NASA contract, is developing the power conversion subsystem; Thomson Ramo Wooldridge, an AI subcontractor, is building the mercury-Rankine cycle combined rotating unit; and RCA's Astro-Electronic Division, an AI subcontractor, is developing advanced thermoelectric material and generator technology. AI will build the reactor and perform system integration.

The experimental reactor (S8ER) performed successfully during a 60-day operating test ending last April. The system functioned at or above 450 kwt (1300°F) during the test.

Testing of a developmental reactor mockup (S8DRM-1) was started in April. It consists of a flight-type reactor and shield assembly but employs dummy fuel elements. The system will be used in simulations of transport, launch, and operating conditions that the actual flight reactor will be subjected to. It is expected to prove SNAP-8 reactor compatibility with the launch and space environment.

● **SNAP safety tests**—Considerable effort has been and is being maintained by the AEC to minimize the danger of radioisotopic contamination or, in the case of space reactors, unintentional criticality or excursion in case of accident during a launch or mission.

In isotopic generators, fuel capsules are designed to maintain their integrity under all expected conditions except re-entry. For the latter condition, capsules are designed to ensure that fuel vaporizes in such a way that the resulting submicron particles would be safely dispersed at high altitudes.

The following tests typify the extent to which the AEC safety efforts have been pressed in recent years:

—To simulate a liquid-engine booster fire on the launch pad, 8,500 lbs. of kerosene and 6,000 lbs. of aniline and nitric acid were ignited over a missile structure containing SNAP-type generator assemblies and bare fuel capsules. The flash temperature reached 5,100°F, the subsequent fire temperature varied from 1,200-2,600°F as recorded during the following 15-minute period, and fuel capsules not only were retained within their associated generators but showed no signs of functional degradation.

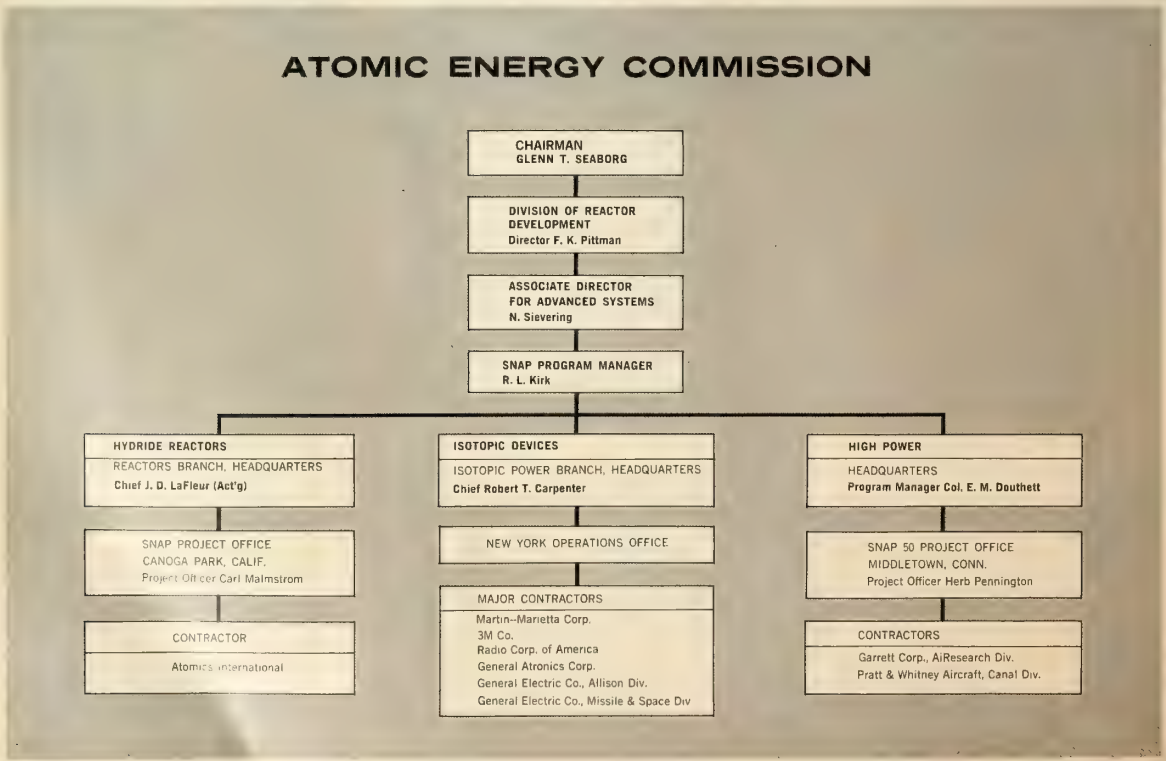
—Similar solid-propellant-missile launch-abort tests were made using over 10,000 lbs. of black powder and propane gas. After 30 minutes burning time and experiencing temperatures of up to 2,900°F, test capsules survived with no detrimental effects.

Generators and isotope containers have been subjected to massive explosions (1,650 lbs. of TNT); furnace-heated and impacted at maximum velocity against granite to simulate a post-launch failure; and dropped from aircraft from different altitudes at varying speeds and over a variety of terrain types to verify simulated impact tests. In all cases, the fuel capsules maintained their integrity.

Another phase of the AEC's safety effort is that involving high-altitude flight tests using a *Scout* vehicle. Called the Re-entry Flight Demonstration, the first successful test system (RFD-1) was launched in May, 1963, from Wallops Island using a SNAP reactor mockup.

Employing a 750-mi. suborbital flight path, the flight had as its principal goal the collection of better design data to establish safety criteria in future flight hardware. RFD-2, launched Oct. 9 from Wallops Island, carried a generic heat-accumulator-block type of isotopic generator. Purpose of the experiment was to study its re-entry behavior and to evaluate ablation rates of fuel and its capsule material.

Ground tests are being performed through use of deliberate excursions of



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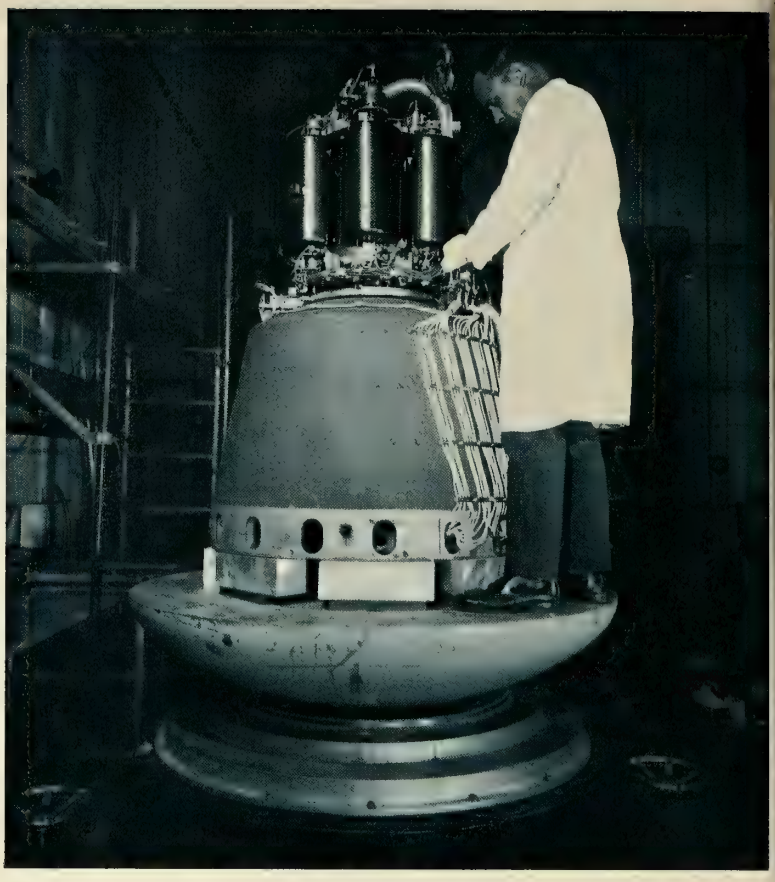
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SNAP-8 mockup will be used for mechanical and thermal tests of components.

SNAP reactors to determine the maximum expected energy release that could occur through accidental reactor criticality. In SNAPTRAN-3, a test last April, simulations were performed covering an abort just after lift-off wherein the reactor impacts in water causing an excursion. Such a situation did in fact occur, but the system disintegrated with no fission-material hazards noted.

A second test to measure energy release will involve an equally unlikely accident—criticality resulting from rotation of a reactor's neutron reflector drum.

● **SNAP-50/SPUR**—Biggest of all the existing reactor-type space APU's now in development is the SNAP-50/SPUR—a joint AEC/Air Force/NASA program. As presently conceived, the program will require a total of $300 million in expenditures through subsystem testing (1970) alone. Of this figure, $60 million will be used for construction and equipment.

Designed to produce outputs from 300 to 1,000 kwe, it will provide a power capability for both electrical systems use in advanced space vehicles and propulsion use for deep-space missions. Such a system would also be applicable for lunar-base operations and for large manned orbital platforms.

The program as presently phased could provide an operational system by the mid-1970's, but much of the required technology for the advanced reactor and energy-conversion subsystem is pressing the state of the art.

Employing a powerplant somewhat similar to that of the other SNAP reactors, SNAP-50 differs considerably in that it employs very high temperatures —using refractory metal alloys, the reactor outlet temperature is about 2,000°F. The result then offers the potential for a very high power output with a relatively low weight (6,000 lbs.) system. Operating life will be about 10,000 hours.

The AEC project office is at CANEL, the Connecticut Advanced Nuclear Engineering Laboratory. Pratt & Whitney Div. of United Aircraft Corp. is prime contractor for the development program.

Principal Air Force contractor is the AiResearch Div. of Garrett Corp., for development of the closed-loop power conversion system. Westinghouse Electric Corp. is developing the generator for AiResearch. ■

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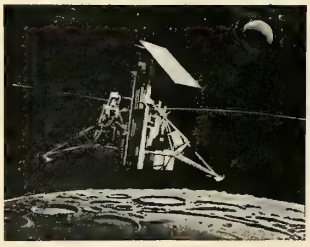
To plan digital simulation for studies related to earth orbital, trans-lunar, interplanetary and reentry trajectories; analog simulation of rendezvous guidance and control systems.

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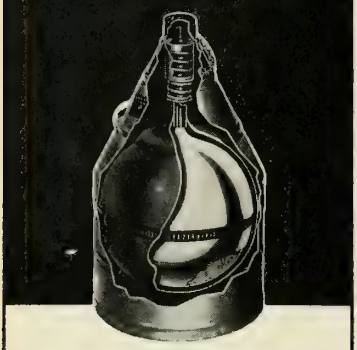
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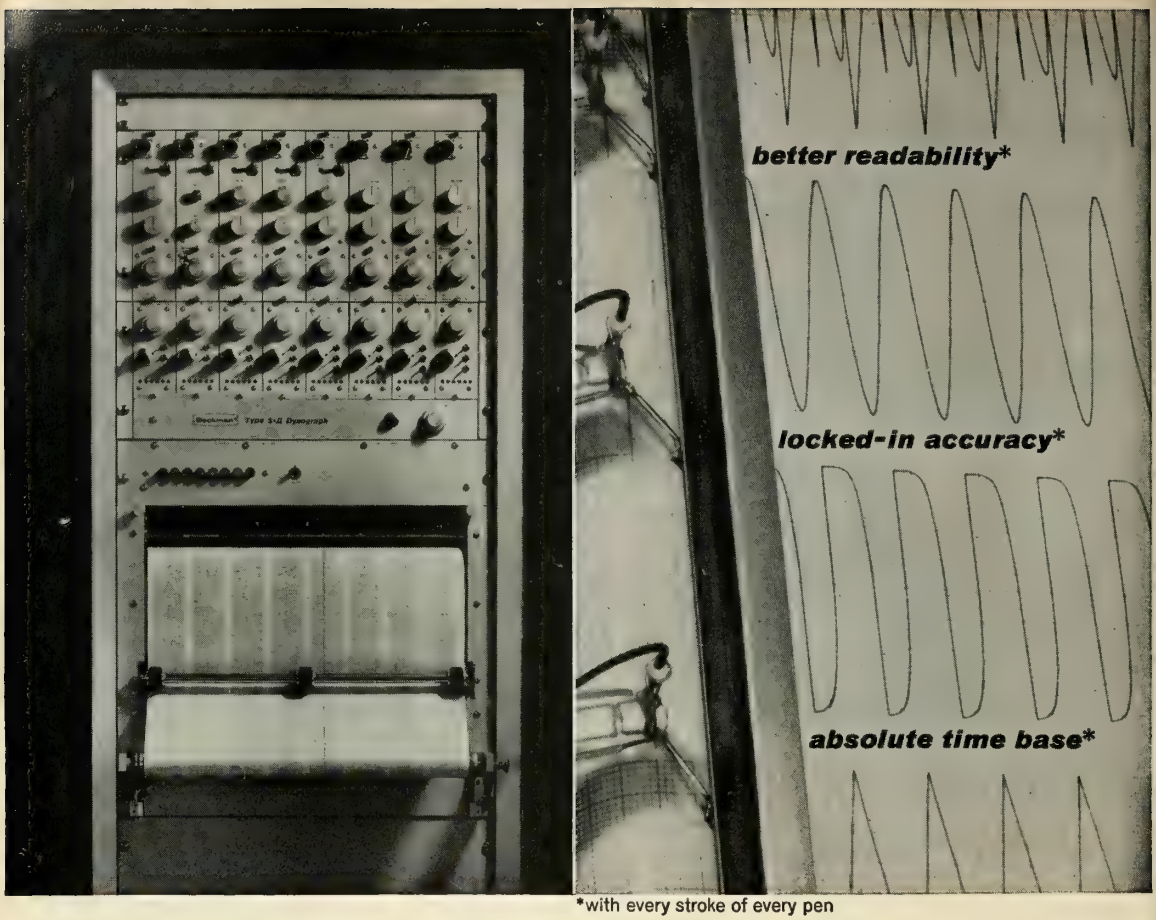
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Versatility...A multitude of inexpensive input couplers allow the conditioning of virtually any type of signal, making unnecessary the purchase of expensive special-purpose amplifier systems.

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SPECIFICATIONS

Number of Channels	1-8 standard
Sensitivity	with preamp, 1 μv/mm to 5 v/mm. without preamp, 1 mv/mm to 5 v/mm.
Frequency Response	DC to 150 cps
Linearity	±0.25%, or less
Drift	1 mm/hr
Input Impedance	1 megohm DC; 1 megohm shunted by 1,000 p.f. or less AC.
Power Required	230 watts, maximum (8 channels)
Input Couplers	28 standard, plus specials

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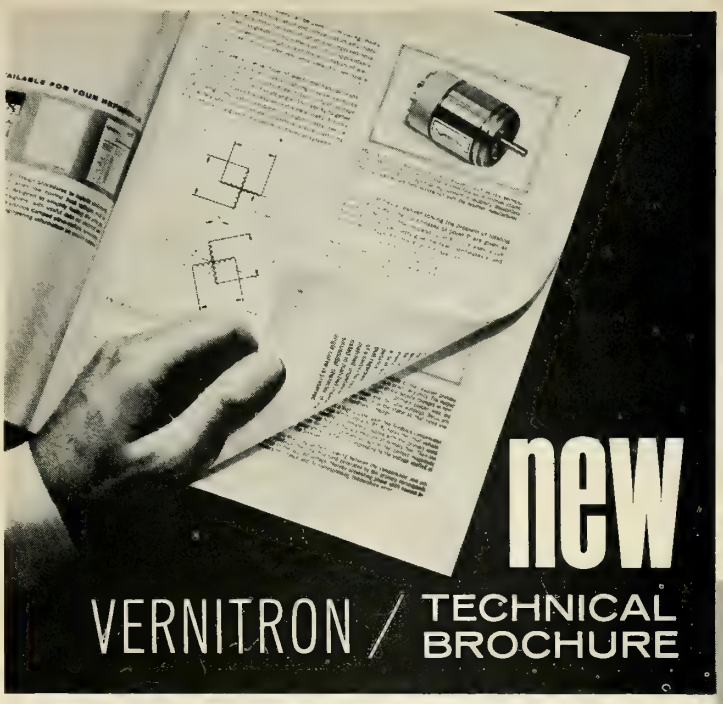
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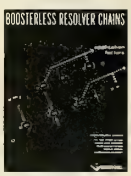
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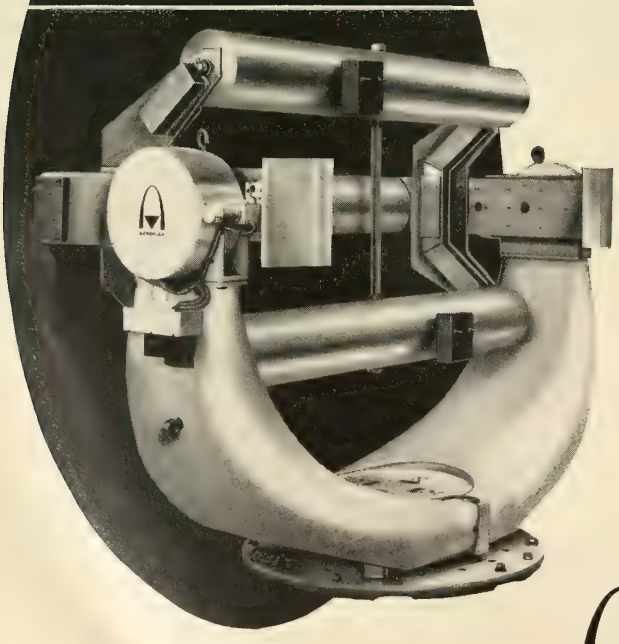
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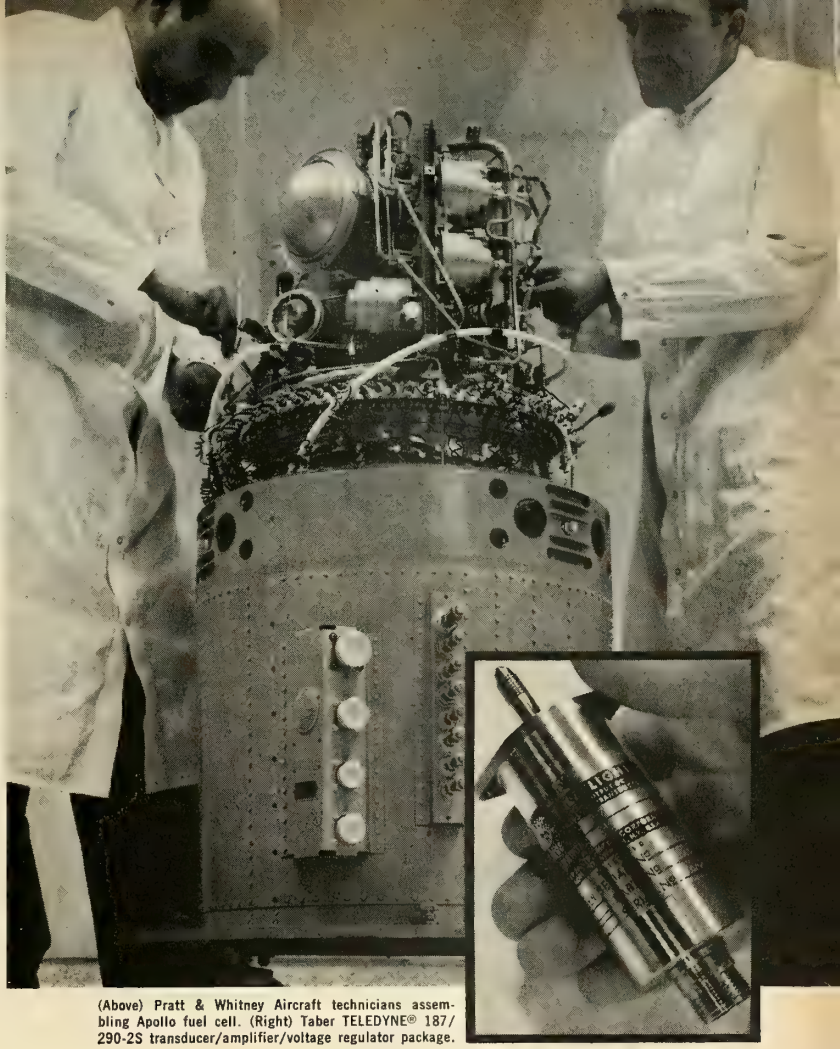
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(Above) Pratt & Whitney Aircraft technicians assembling Apollo fuel cell. (Right) Taber TELEDYNE® 187/290-2S transducer/amplifier/voltage regulator package.

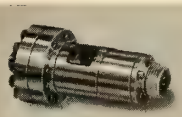
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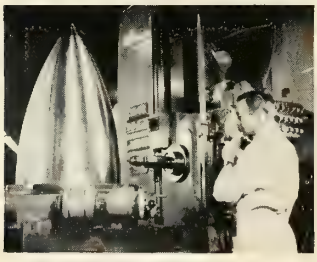
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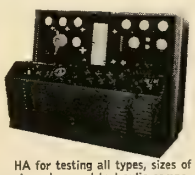
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Honeycomb is a continuum of uniform two dimensional geometry which can extend infinitely in the third dimension.

GEOMETRIC CHARACTERISTICS:

1. It has stabilized hexagonal, columnar cells.
2. It is a composite of parallel, uniform cells sharing common walls.
3. It has high surface area to volume.
4. It has high free area to volume.

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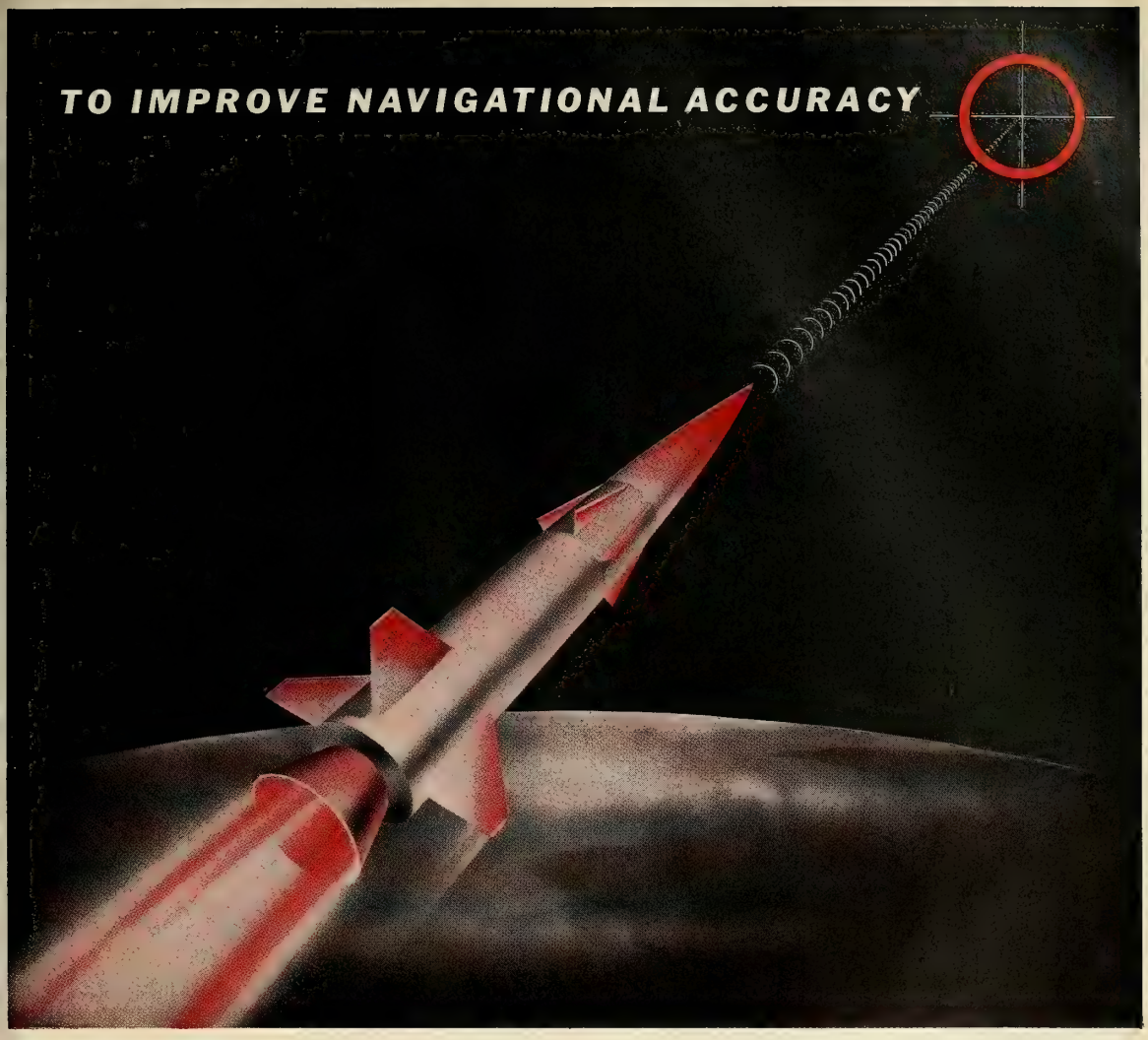
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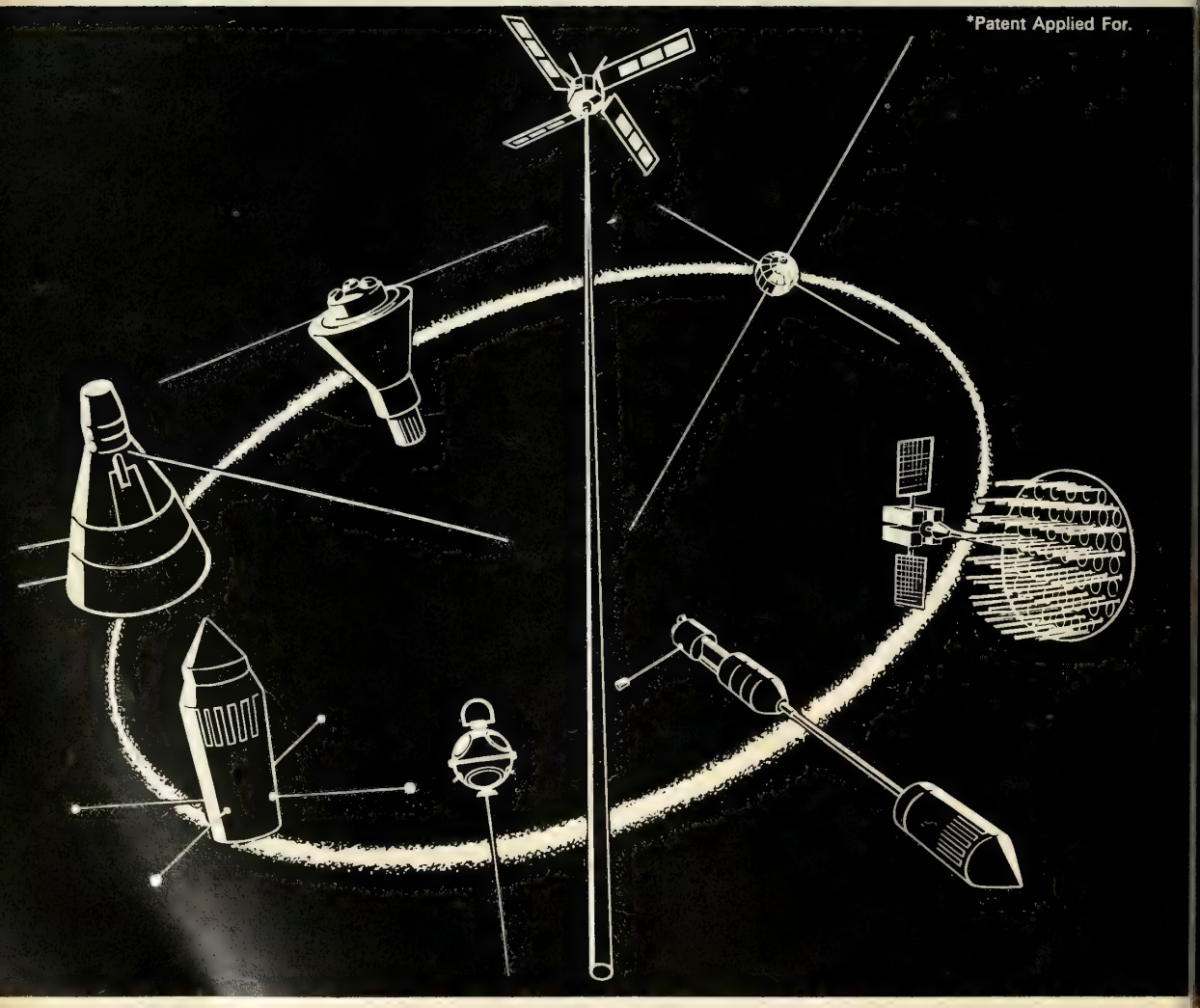
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BREAKTHROUGH IN SPACE

STEM* (Storable Tubular Extendible Member) devices have proven performance in many applications, placing the engineering and production abilities of de Havilland SPAR Division in the forefront of aerospace engineering. Size, weight, packaging, density, structural and other hitherto major problems in such confined areas have been overcome, resulting in new and advanced engineering solutions.

Here are some of the STEM developments that have contributed to the advancement of space science: communications antenna and arrays in sizes to fit many applications; long gravity gradient orientation booms, and attitude control devices; STEM devices for remote positioning of navigation, communications and instrumentation; high gain antennas and reflectors; extendible coupling and docking devices; and de-spin and stabilization devices.

*Patent Applied For.



De Havilland STEM devices are on these and many other programs; Alouette, LOFTI, NASA Javelin, Scouts, TRAAC, Transit, Gemini, Mercury, POGO.

THE DE HAVILLAND AIRCRAFT OF CANADA LIMITED

SPECIAL PRODUCTS & APPLIED RESEARCH DIVISION

Malton Ontario

A-429

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—contracts and procurements—

AWARDS

AIR FORCE

$1,166,211—**Hewlett-Packard Co.,** Palo Alto, Calif., for fabrication of oscilloscopes.

$499,950—**Texas Instruments, Inc.,** Semiconductor Components Div., Dallas, for molecular electronics for radar applications.

$325,300—**Paul Hardeman Inc.,** Stanton, Calif., for fabrication, installation and test of propellant test system.

$120,000—**Radio Corp. of America,** Missile & Surface Radar Div., Moorestown, N.J., for maintenance and supply support for designated instrumentation radars.

$106,629—**Hycon Manufacturing Co.,** Monrovia, Calif., for an image motion analysis, evaluation and measurement technique.

$70,000—**Auerback Corp.,** Philadelphia, to design the storage and retrieval system for what will be the largest store of computer-processed reliability information in the world.

$64,781—**Rocket Power Inc.,** Mesa, Ariz., for research in chemical synthesis with monoenergetic ions.

$41,635—**North American Aviation, Inc.,** Downey, Calif., for a bioastronautics laboratory research tool study.

$37,000—**Radio Corp. of America,** Aerospace Systems Div., Van Nuys, Calif., for displays development work.

$30,705—**University of Hawaii,** Honolulu, for an investigation of problems in information, transmission and processing.

$27,600—**The Boeing Co.,** Aerospace Div., Seattle, for a six-degree-of-freedom spacecraft vehicle simulation training program.

ARMY

$1,206,895—**Philco Corp.,** Newport Beach, Calif., for production of electronic equipment.

$365,200—**Sperry Rand Corp.,** Long Island City, N.Y., for a feasibility study and development of a settable inertial altitude sensor and associated setter and tester equipment for use on high-g missiles.

$344,749—**Astro-Space Laboratories, Inc.,** Huntsville, Ala., for machinery, fabrication and assembly of *DC-MAW* thrust floated gyro for the *DC-MAW* system.

$75,000—**Bendix Corp.,** Systems Div., Ann Arbor, Mich., for design, fabrication and installation of TV tracker system.

$44,933—**Advance Electronics Corp.,** Hicksville, N.Y., for telemetering transmitter kit.

$31,700—**Baird-Atomic Inc.,** Cambridge, Mass., for a classified study.

$21,406—**Bethlehem Steel Co.,** Bethlehem, Pa., for cup forging for the *DC-MAW* weapon system.

NAVY

$7,830,438—**Sperry Rand Corp.,** Sperry Gyroscope Co., Syosset, N.Y., for engineering services on an inertial navigation system for submarines.

$1,758,000—**General Electric Co.,** Washington, D.C., to manufacture, assemble, test and furnish one *Polaris* fire control system for training use.

$1,315,575—**Radiation, Inc.,** Palm Bay, Fla., for modification of satellite communications equipment aboard the satellite communications ship USNS Kingsport.

$530,000—**United Aircraft Corp.,** United Technology Center, Sunnyvale, Calif., for continued research and development in hybrid rocket combustion and investigation of improved throttling for liquid rocket engines.

$388,006—**Vitro Corp. of America,** Vitro Laboratories, Silver Spring, Md., for engineering services and studies related to ASW fire control systems.

NASA

$2,296,249—**Westinghouse Electric Corp.,** Aerospace Div., Baltimore, for a LEM television camera.

$1,330,040—**Chicago Bridge and Iron Co.,** Pasadena, Calif., (awarded in conjunction with the Atomic Energy Commission) to fabricate and install two 500,000-gal. liquid hydrogen storage vessels and one 225,000-gal. water storage tank at the Nuclear Rocket Development Station, Nev., in connection with Project *Rover*.

$466,000—**General Telephone & Electronics Corp.,** Sylvania Electric Products, Inc., New York City, to design and develop a "counter-spun" antenna for an advanced technological satellite that will spin like a gyroscope as it circles the Earth in a 22,000-mi.-high orbit.

$332,000—**Sonex, Inc.,** Philadelphia, for a telemetry modulation system.

$324,500—**Radio Corp. of America,** Aerospace Systems Div., Van Nuys, Calif., for *Saturn* checkout displays.

$288,180—**Pall Corp.,** Environmental Control Systems Div., Long Island City, N.Y., for research and development of transportable ground support cooling units.

$235,000—**Atomic Energy Commission,** Washington, D.C., for development of methods of producing ultra-high purity uranium dioxide particles cladding tungsten-uranium composites by plasma spraying and chemically analyzing for trace impurities in tungsten-urania composites.

$148,579—**General Electric Co.,** Missile and Space Div., Philadelphia, for

REFRACTORY METALS APPLICATION NOTES

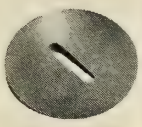
Only G.E. gives you 3 classes of molybdenum sheet, each with specified reproducible mechanical properties. You buy only the quality your application requires.



CLASS 100 Highly engineered, precision rolled moly sheet with specified reproducible mechanical properties. Processed for optimum strength and ductility at room temperature. Use it for demanding applications such as difficult deep drawing and severe die forming. Available in widths from ⅛″ through 12″.

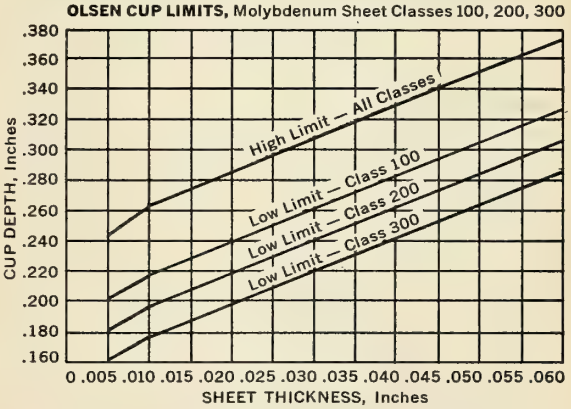


CLASS 200 General purpose moly sheet with specified reproducible mechanical properties. Use it for less demanding applications where the more highly defined mechanical properties of Class 100 are not needed. Available in widths from ⅛″ through 24″.

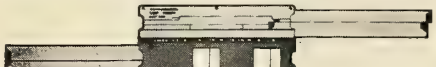


CLASS 300 Moly sheet with limited, specified reproducible mechanical properties. Use it for simple forming and blanking where less critical limits of mechanical properties, tolerances, finish and flatness are required. Available in widths from ⅛″ through 24″.

The specified minimum ductility of each class of molybdenum sheet, as determined by the Olsen Cup Test*, is shown below.



*Olsen Cup Test—a cupping test in which a metal sheet, restrained except at the center, is deformed by a standard steel ball until fracture occurs. The height of the cup upon fracture is a measure of ductility.



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GENERAL ELECTRIC



SPACE SYSTEMS ENGINEERS

The momentum generated by the LEM and other space-oriented programs make Grumman a unique professional environment for engineers and scientists who can contribute to the successful culmination of the project in the late 1960's.

Technical perspective is the indispensable requirement of the space systems engineer. Facing increasingly higher levels of performance in alien environments, he makes the critical decisions as he weaves all relevant "state of the art advances" into the fabric of the system. Borrowing discriminately from many disciplines, sifting, selecting and incorporating elements that can accomplish the technical goals of the system, Grumman engineers are transforming advance ideas into reality. Qualified individuals interested in growth with stability are invited to investigate these specific opportunities:

Systems Coordination Engineers— will coordinate a program that organizes, validates and controls the overall functional requirements of an advanced manned spacecraft project fulfilling project objective as prescribed by the procuring agency. These functional requirements are translated into over-all vehicle performance and design requirements, establishing systems parameters from which the vehicle, its major subsystems, and support equipment are designed. Task assignments include: internal and external liaison with design specialists & systems personnel & direction of the incorporation of established requirements into top systems and vehicle specifications. Applicants should possess a BS or MS in ME, EE or Physics and a minimum of 3 years of systems analysis or integration experience in a major systems effort.

Systems Engineers—Facility and Services—BS or advanced degree with a minimum of 2 years experience in establishing the requirements for facilities and the criteria for the evaluation of existing facilities. Applicants will be required to survey tests and operational sites both ashore and afloat to verify weapon system compatibility with existing facilities and support equipment. Ability to recommend and/or originate solutions to preclude potential interface difficulties is necessary. Recent military experience and/or good working knowledge of military organization desirable.

Control Systems Engineers—BS or advanced degree with experience in design analysis and integration of vehicle control systems. Applicants should possess a working knowledge of servo analysis techniques and subsystem and component hardware development. Position entails conceptual work in defining control systems, establishing subsystem and component requirements, system development and verification.

Senior Heat Transfer Engineers — BS or MS with minimum of 5 years training and experience in structural heat transfer analysis is required. Will develop IBM programs and other analytical tools as needed to handle complicated configuration and end condition for space vehicle structures and propulsion systems. Must be capable of determining temperature distributions and recommended heat transfer configurations for initial structural designs and the detailed analyses, and test verification work to complete the design.

Rocket System Performance Analysts — Degree in Engineering, Physics or Chemistry with a minimum of 3 years experience in Liquid Rocket Development, test and analysis. Knowledge of small pulsed rocket engines and pressure fed propellant systems is very desirable.

Fluid Mechanics Engineers — BS in AE or ME with 2 or more years experience in internal aerodynamics, duct pressure drop analyses or compressible fluid flow. Familiarity with aircraft or spacecraft propulsion systems desirable.

Propulsion System Analysts — BS or MS with a minimum of 3 years experience in rocket propulsion analysis and system simulation, using analog techniques. A good knowledge of liquid rocket feed systems, component characteristics, dynamic interactions, and vibration effects, is very desirable. Will be responsible for the development, test, and utilization of liquid rockets in manned space vehicles.

To arrange an immediate interview, SEND RESUME to Mr. P. M. Van Putten, Manager Engineering Employment, Dept. GR-86.

GRUMMAN

AIRCRAFT ENGINEERING CORPORATION

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an experimental analytical investigation of a circularly polarized 500 to 5,000-w band plasma accelerator.

$138,934—**Electro-Optical Systems, Inc.,** Pasadena, Calif., for a high enthalpy gas heater development for materials test facility.

$132,550—**System Engineering Laboratories, Inc.,** Fort Lauderdale, Fla., for a digital data acquisition system.

$99,900—**General American Transportation Corp.,** Mechanical Research Div., Niles, Ill., for a lunar survey probe sensor study.

$99,000—**Radio Corp. of America,** Defense Electronic Products, Camden, N.J., for solar-pumped magnetically modulated laser communication system study.

$97,713—**United Electrodynamics Inc.,** Pomona, Calif., for PCM subcommutators.

$96,000—**Kollsman Instrument Corp.,** Space Div., Syosset, N.Y., for a lunar survey viewfinder study.

$86,228—**Philco Corp.,** Western Development Laboratories Div., Palo Alto, Calif., to conduct a study to determine guidance component requirements for a manned Mars mission.

$74,457—**Space Labs, Inc.,** Van Nuys, Calif., for a field support team.

$64,930—**Lear-Siegler Inc.,** Power Equipment Div., Cleveland, Ohio, to design, develop, fabricate and test two electro-mechanical actuation systems.

$63,860—**Melpar, Inc.,** Falls Church, Va., to investigate methods to control microbial growth in manned spacecraft.

$63,000—**Beckman Instruments, Inc.,** Fullerton, Calif., for ultraviolet density sensor.

$45,205—**TRW/Space Technology Laboratories,** Redondo Beach, Calif., for additional work on investigation of flight load prediction techniques.

$44,000—**Union Carbide Corp.,** Carbon Products Div., New York City, carbon electrode development program.

$38,250—**Avco Corp.,** Tulsa Div., Tulsa, Okla., to build precision cleaning equipment.

$37,000—**Wilmore Electronics Co., Inc.,** Durham, N.C., for research to develop improved techniques for power conditioning for ion thrustor application.

$36,025—**Carbons, Inc.,** Boonton, N.J., for carbon electrode development program.

$21,508—**Engineered Electronics Co.,** Santa Ana, Calif., for the design and manufacture of a large, digital module electronic system and associated equipment, especially designed to provide a method of self teaching and reviewing of digital principles.

Westinghouse Electric Corp., Atomic, Defense and Space Group, Baltimore, to assist in evaluating the performance of a British-American satellite (amount undisclosed).

INDUSTRY

$6,100,000—**Cessna Aircraft Co.,** Wichita, Kan., from **McDonnell Aircraft Corp.,** St. Louis, for follow-on production contract for missile ejection racks, missile pylons, bomb racks and wing pylons.

$200,000—**Seaport Company,** Seattle, from **The Boeing Company,** Seattle, to supply grinding wheels.

$120,000—**Radio Corp. of America,** Aerospace Systems Div., Burlington, Mass., from **Grumman Aircraft Engineering Corp.,** Bethpage, N.Y., for engineering assistance on LEM.

$100,000—**Sequential Electronic Systems, Inc.,** Elmsford, N.Y., from **General Precision Inc.,** Aerospace Group, Little Falls, N.J., for development and production of a state-of-the-art centrifuge.

ATOMIC ENERGY COMMISSION

$3,215,000—**Sylvania Electric Products, Inc.,** Electronic Defense Laboratories, Mountain View, Calif., for engineering services to perform research and development in the field of electronic ware.

$1,330,040—**Chicago Bridge and Iron Co.,** Pasadena, Calif., (awarded in conjunction with the National Aeronautics and Space Administration) to fabricate and install two 500,000-gal. liquid hydrogen storage vessels and one 225,000-gal. water storage tank at the Nuclear Rocket Development Station, Nev., in connection with Project *Rover*.

ADVANCED RESEARCH PROJECTS AGENCY

$138,203—**Radio Corp. of America,** Communications Systems Div., Cambridge, Ohio, for bundle drop marker beacon designs in connection with Project *Agile*.

REQUESTS FOR BIDS

GENERAL PROCUREMENTS

Lewis Research Center
21000 Brookpark Road
Cleveland, Ohio 44135

LRC issued RFP No. 202967 Nov. 22, 1964, for the development of processes to produce oxide fibers for use in reinforcement of metals to achieve a fiber composite material for elevated temperatures. Contact Mr. Sherwood Holman at LRC.

Lewis Research Center
21000 Brookpark Road
Cleveland, Ohio 44135

RFP 202970 issued during week of Nov. 22, to conduct an experimental testing program to develop oxidation resistant materials for transpiration cooled gas turbine blades. Contact Mr. Sherwood Holman.

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MISSILES AND ROCKETS november 30 1964

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Lewis Research Center
21000 Brookpark Road
Cleveland, Ohio 44135

RFP 202969 issued during week of Nov. 22; requires contractor to develop coatings which will protect tantalum alloys from oxidation and interstitial contamination. Requests for copies should be forwarded to Mr. T. Donohoe.

Air Force Special Weapons Center
Procurement Directorate
Attn: SWMKB
Kirtland AFB, New Mexico

Continuation of research studies for countermeasures to high temperature X-radiation. This notice is not for solicitation of additional proposals but is issued for the benefit of prospective subcontractors with appropriate security clearance. Those interested should contact Philco Aeronutronic Division, a subsidiary of Ford Motor Co., Newport Beach, Calif.

Defense Communications Agency
Code 260
Washington, D.C.

DCA proposes to procure single-source, R&D study necessary to provide display programming, investigations and development to support TEMPER and other war gaming models with their display subsystems and to provide the technical support required by the NMCSSC. For information only; RFP not available.

NASA Headquarters
Contracts
Washington, D.C. 20546

Continuation study to develop advanced solid propellants containing uncoated oxidizer. NASA is negotiating with Thiokol Chemical Corp., Elkton, Md. 21921. For information only; RFP not available.

Directorate of R&D Procurement
Systems Engineering Group
Research and Technology Division
Wright-Patterson AFB, Ohio 45433

Negotiations will be conducted with Westinghouse Electric Corp., Dayton, Ohio, to develop the dynamic conversion subsystem for use in a power conversion concept utilizing a nuclear reactor as a source of energy and operating on a high temperature ranking cycle with liquid metal working fluids. This is a continuation of a present contract. For information only; RFP not available.

Procurement Division
Code 247, Section B
Goddard Space Flight Center
Greenbelt, Maryland 20771

Contract for *Applications Technology Satellite (ATS)* ground system to be negotiated with Westinghouse Defense and Space Center, Baltimore. For information only; RFP not available.

Purchasing Office
George C. Marshall Space Flight Center
Huntsville, Alabama 35812
Attn: PR-ES, R. A. Parsley

Marshall Space Flight Center proposes to negotiate with the Grumman Aircraft Engineering Corp. for an eight-month study on man-system locomotion hand controls and panel display concepts for maneuverable extraterrestrial vehicles. For information only; RFP not available.

NASA Manned Spacecraft Center
General Research Procurement Branch
2101 Webster-Seabrook Road
Houston, Texas 77058
Attn: Aubin O. Ferguson

Negotiations will be conducted with Aerojet General Corp., Houston, for a program to determine the blast parameters and fireball characteristics associated with explosions and deflagrations of various propellants. For information only; RFP not available.

NASA Headquarters
Washington, D.C. 20546

NASA is negotiating with Grumman Aircraft Engineering Corp., Bethpage, N.Y., for a study of the *Orbiting Astronomical Observatory*. For information only; RFP not available.

Contracting Officer
National Aeronautics and Space Administration
Langley Station
Hampton, Virginia

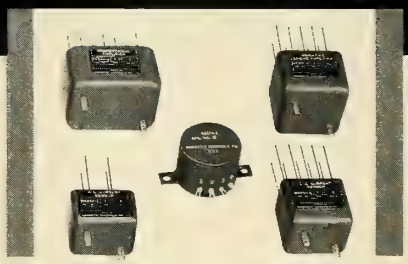
Negotiations for theoretical flow field calculation for Project RAM are being conducted with North American Aviation, Inc., Downey, Calif. For information only; RFP not available.

U.S. Army Missile Command
Redstone Arsenal, Alabama

Research and development for the *Hawk* system: the requirement for experience in highly technical principles and processes which are available only from the prime contractor for the *Hawk* motor precludes award to other than Aerojet-General Corp., Sacramento, Calif. All inquiries relative to subcontracting should be referred to Aerojet.

WE HELPED SOLVE THE THERMAL CONTROL PROBLEMS IN THE IMU SYSTEM FOR APOLLO





THIS IS HOW WE DID IT!

1. We were already manufacturing to rigid NASA specs and qualified our proposed system components under NPC 200-3 inspection system provisions. We

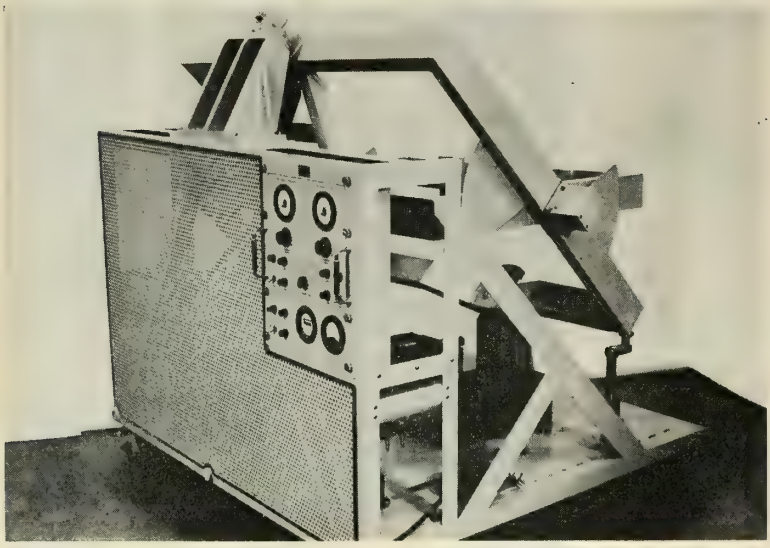
2. thoroughly analyzed the reliability specs and decided on a system that used previously proven solid state amplifiers. These amplifiers were qualified to respond to temperature system accuracies of .05°F. We added a unique current sensor of our own design (completely linear input/output, current/voltage relationship) and packaged the components. Specifically we employed our MA20, MA25, MA17, MA16, RU27, PA36. This gave us temperature control, redundant temperature control and alarm systems. From the standpoint of size and weight, the system is at least equal to any known micro-miniaturized circuitry and,

3. complies with ND1015404 Class I. Frankly, we felt pretty good about this project. Not many companies can produce precision temperature control systems of this magnitude, accuracy, and reliability.

■ We like to think that if you have a temperature control problem of some complexity, you'll ask us! Chances are we'll have an answer.

MILITARY SYSTEMS DIVISION
MAGNETIC CONTROLS COMPANY
6405 CAMBRIDGE ST., MINNEAPOLIS 26, MINNESOTA

Circle No. 82 on Subscriber Service Card



New Product of the Week:

Aeroflex Tilt Table

A tilt table, featuring a two-gimbal mounting system, which tests platforms with harmonic oscillatory motion in the roll, pitch and azimuth axes, is being manufactured by Aeroflex Laboratories, Inc.

The Model ARX-208 has an outer gimballed frame, inclined at 45 degrees, to control both azimuth and pitch motion. The inner, horizontal frame adds roll motion. Both provide adjustable amplitude control up to ±10 degrees at cyclical rates from 0.05 to 1.0 cps.

The table operates on 115v, 60 cps. Operating current varies with table speed and amplitude to a maximum of 7 amperes.

Circle No. 151 on Subscriber Service Card

Cryogenic Valves

A series of cryogenic valves for handling streams such as liquid hydrogen, liquid helium, cold gaseous helium and rare and/or toxic gases is available from Cryovac, Inc.

The V-1060 series are globe-type valves in the 150-lb. A.S.A. class. They are available in five sizes, ranging from 0.5 to 2 in. Three modes of operation —manual, cylinder and positioner—are available.

The valve features a vapor-seal that isolates all mechanical seals in the valve from cryogenic temperatures. It provides a long, thin cavity filled with gas that has a temperature gradation ranging from the temperature of the process stream to ambient temperature near the "O" ring seals.

Circle No. 152 on Subscriber Service Card

Silicon Strain Gage

A single-crystal silicon strain gage for rocket propellant flow metering has been developed by Electro-Optical Systems, Inc. The device is capable of withstanding temperatures up to 1,000°F and continued immersion in both static fuels and oxidizers, the firm says.

The gage uses a proprietary active element diffusion technique on a single crystal silicon substrate. It has a four-active-arm Wheatstone bridge for strain measurement with an additional resistor on the same layer for temperature measurement.

According to EOS, the device is expected to operate over a temperature range of −100° to 150°F. Resistance is 450 ohms; gage factor is 60.

Circle No. 153 on Subscriber Service Card

Precision Potentiometer

The Model 7P48, a 30-in. rectilinear precision potentiometer, is available from Markite Corp.

A combination of infinite resolution and the ability to operate while immersed in clean hydraulic and other non-conducting fluids is said to permit accurate operation and direct coupling, thus eliminating the problems and errors introduced by gears, including back lash. Units may be specified with terminal posts, connectors or wires for electrical connection to servo and other systems.

Standard independent linearity for the device is ±0.2% with special accuracies available to ±0.01%. Standard units are furnished with single resistance elements, ranging from 5k to 50k ohms in the 30-in. length; dual elements can be specified, as well as taps at required locations.

Conservative figures for units already in service indicate a life expectancy of over 10 million cycles, whether mounted in air or in fluid, within the operating ambient of −65° to 125°C, the company says.

Circle No. 154 on Subscriber Service Card

Digital Tape Transport

A digital tape transport featuring a servo-driven, single-capstan drive designed for low tape wear and reduced maintenance has been developed by Ampex Corp.

The TM-11 operates at 75, 112.5 and 120 ips. Data transfer rate is 96,000 bits/second. The unit is capable of packing 800 bits of information per inch of computer tape.

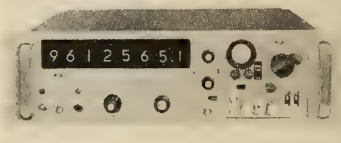
The drive system is said to utilize 80% fewer mechanical parts than conventional transport drive mechanisms. All sliding friction between the tape's oxide surface and the transport is eliminated, except across the read/write head and the tape cleaners, Ampex says.

Circle No. 155 on Subscriber Service Card

Measuring System

Systron-Donner Corp. has introduced a high-frequency measuring system that covers the range of dc to 15 gc. The system consists of a 50-mc counter-timer and a 15-gc transfer oscillator plug-in.

Counter accuracy is maintained over the entire range by means of a combination of AFC and phase lock for CW signals. Phase lock holds over a ±0.01% shift of the measured signal. The unit measures 5.25 in. high.



Circle No. 156 on Subscriber Service Card

Hydrophone

A line-array directional electro-acoustical hydrophone, the Model L.H.-41, has been developed by Sparton Electronics Div. of Sparton Corp.

The device uses piezoelectric ceramic elements in a flexural arrangement and features a minimum storage volume. Characteristics include: receiving sensitivity in db/lv/μbar of −87 minimum; capacitance at 1 kc in μμfd or 10,000; nominal operating pressure of 135 psi; operating temperature range of −55° to 71°C. Cable length is 300 ft.; diameter is 0.065 in. ±0.01 in.

Circle No. 157 on Subscriber Service Card

Coaxial Magnetron

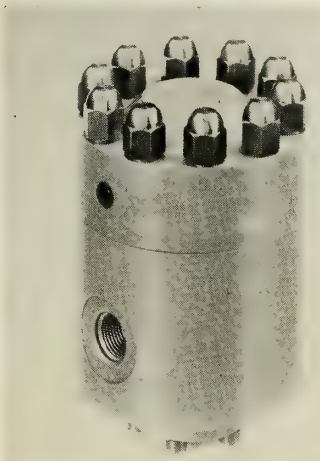
S-F-D Laboratories, Inc., has introduced a Ka-band ICEM® coaxial magnetron, the Model SFD 335.

The 8.9-lb. unit delivers 125-kw peak power output at a fixed frequency in the range 34.5 to 35.2 gc. Production fixed frequency tubes are supplied to within ±50 mc of the customer's designated center frequency. The tube, warranted for 1,000 hours, is said to be suited for airborne, ground transportable and mobile system applications. Output is in circular waveguide (WC-59).

Circle No. 158 on Subscriber Service Card

Pressure Regulator

Controls Div. of Victor Equipment Co. is marketing a dome-loaded pressure regulator for such functions as con-



trolling gases or liquid when combining fluids and/or gases, introducing fluids into semi-solids or viscous liquids and injecting oxygen.

The units are available in bronze and stainless steel for pressures to 6,000 psig and in aluminum for pressure to 3,600 psig. Air flow rate is 7,000 scfm at 70°F. Operating temperature range is −65° to 500°F.

Circle No. 159 on Subscriber Service Card

Analog Switches

Two microcircuit analog switches, PC-401 and PC-402, have been developed by General Instrument Corp. for use in microelectronic digital-to-analog converters.

PC-401 is a single input switch; PC-402 is a double, or complementary, input switch. Both units measure 0.375 in. sq. and 0.085 in. thick.

Circuit performance characteristics include: turn-on delay time, typically 0 nanosecs and maximum 50 nanosecs; rise time, typically 50 nanosecs; turn-off delay time, typically 100 nanosecs; repetition rate, minimum 200 kc.

Circle No. 160 on Subscriber Service Card

Photomicrograph Analyzer

An electronic flying spot particle analyzer for quantitative studies of particle structure of metal alloys and polycrystalline materials has been developed by Airborne Instruments Laboratory.

The instrument scans photographs of metallurgical sections taken through electron or light microscopes and makes a series of complex measurements of the microstructure in a few seconds.

TRAILERS FOR THE SPACE AGE by *DORSEY*

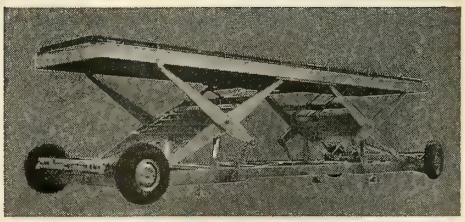
Dorsey has built a record of reliability during two decades of handling a variety of defense assignments and the versatility of our engineering and production departments is demonstrated by the current projects illustrated here. For virtually any type of specialized mobile equipment our Special Products Division engineers help prime contractors and defense agencies hold time and cost to a minimum.

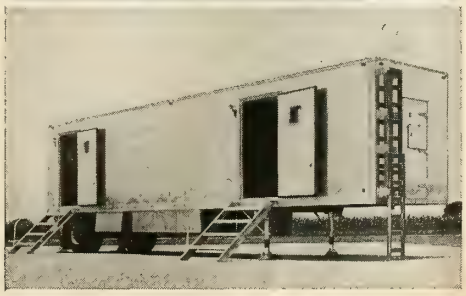
TOP: Full trailers to transport NIMBUS spacecraft, built for Goddard Space Flight Center.

CENTER: Elevator-platform trailer designed and built by Dorsey to raise and lower cargo into and out of aircraft. Contract placed by Marshall Space Flight Center.

BOTTOM: Electronics van to house equipment for monitoring acoustical environment around large space vehicles being static fired, built for the Marshall Space Flight Center.







Write for our brochure, "Mobile Support Equipment"



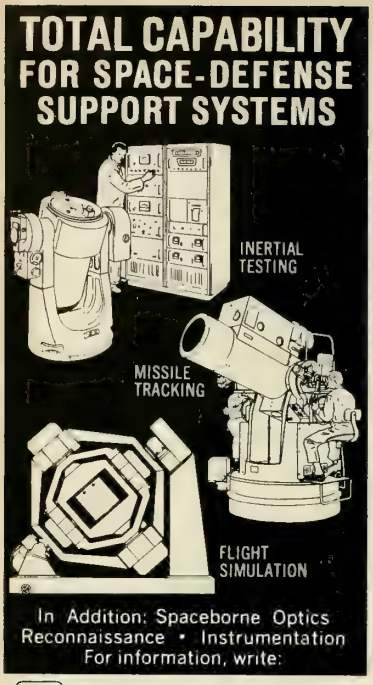


Special Products Division

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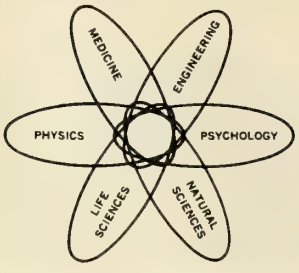
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Circle No. 90 on Subscriber Service Card



AMERICAN OPTICAL COMPANY
Space-Defense Division
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Circle No. 85 on Subscriber Service Card



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Circle No. 86 on Subscriber Service Card

The two-dimensional measurement of geometric relationships between components is accomplished by scanning the film with a 2,000-line raster on a CRT. The scanned field of the film is about 20 x 20 mm. The scanner can resolve and measure images as small as 20 microns on the field, corresponding to 1/100 micron of the original sample taken at 2,000-X magnification.

Circle No. 161 on Subscriber Service Card

Galvanometer Amplifier

Dynamics Instrumentation Co. has available a solid-state 30-kc bandwidth dc amplifier for use with low-level transducers and high-frequency galvanometers.

The device offers gain steps of 0.5, 1, 2, 5 and 10 coupled with a continuously variable multiplier, providing overlapping gain steps up to 25. Noise is 15 μv RMS or less referred to the input in a 30-kc bandwidth. Input impedance is 100,000 ohms at any gain setting; the instrument can withstand 200v peak at input without damage. Overload recovery is less than 1 millisec. Gain stability is ±0.1% of setting for 40 hours after a 30-min. warmup.

Output is ±10v at 100 ma. Output impedance is less than 1 ohm resistive. Power consumption is 105-130v, 60 cps. Operating environment is 0 to 50°C.

Circle No. 162 on Subscriber Service Card

Periodic Antenna

A welded aluminum periodic antenna which operates over the 40 to 1,000-mc frequency range has been developed by Litton Industries for surveillance and tracking.

The Model 11E4-100 features right, or left-hand circular polarization by remote control selection; 9 ±1 db gain; less than 2:1 VSWR and side lobes of more than 20 db below the main beam. The cantilever-mounted log periodic weighs 50 lbs. and measures 16 ft. All components are sealed or sheltered from the weather; the antenna withstands 100 mph windloading with radial ice of 0.5 in.

Circle No. 163 on Subscriber Service Card

Coaxial Attenuators

A 2.0 to 12.4-gc variable coaxial attenuator with a 0 to 40-db attenuator range has been developed by Narda Microwave Corp.

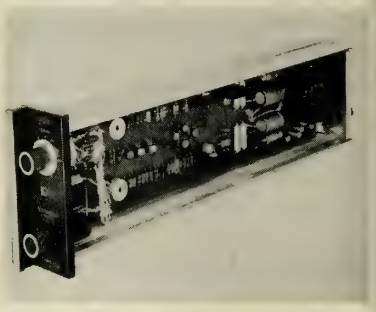
The Model 791 features a maximum insertion loss of 0.75 db, VSWR of 1.30 maximum and power-handling capability of 10 watts (average) / 5 kw (peak). A duo-dial drive is said to provide easier resetting and positive locking. For lower frequency use—2.0 to 2.5 gc—the attenuation range is 0 to 35 db.

Circle No. 164 on Subscriber Service Card

DC Amplifier

A self-contained differential dc amplifier involving no signal transformers and no modulators is available from Neff Instrument Corp.

The Type 110 is an all-silicon, solid-



state device. Specifications include: differential input with 5 megohms input impedance; output of ±10v into 100 ohms with less than 0.5-ohm output inpedance; frequency of 1% dc to 12 kc, 3 db at 80 kc; linearity of ±0.01% f.s.; rise and settle time of 2 ms to 1%, 100 ms to 0.1%.

Circle No. 165 on Subscriber Service Card

Motor-Tachometer

McMaster Products Corp. is marketing a Size 8 motor-tachometer featuring a total inphase output ratio change of ±1%. Total phase shift change is ±2 degrees over a temperature range of −55° to 125°C.

If required, units can be compensated to yield a total in-phase output ratio change of ±0.5% over the complete temperature range. In-phase null voltage of the tachometer is held to 0.005v RMS maximum while the total in-phase axis error change with respect to the temperature range is ±0.005v maximum. Scale factor is 0.55v per 1,000 rpm at a maximum power input of 1.8 watts. Maximum operating temperature is 165°C and the unit meets or exceeds MIL-E-5272C specifications.

Circle No. 166 on Subscriber Service Card

Core Memory

A large-capacity coincident current core memory for computers with a 1-ms cycles time is being marketed by Ampex Corp.

The RS provides 1-ms operation with storage capacities of 4,096, 8,192, 12,228 and 16,384 words by 8 to 56 bits. Increased speed is obtained by use of a magnetic module using 22-mil nickel-ferrite cores. Operation modes of the RS are read-restore, clear-write and read-modify-write. Control signals are read-request, write-request and ready-modify-write.

Circle No. 167 on Subscriber Service Card

Electrometer

A precision electrometer, capable of use in detection of ultra-small electrical potentials from high impedance sources, is being marketed by Electro-Mechanical Development Co.

The instrument is a null indicating device providing sensitivities in excess of 10,000 divisions per volt or 5.7×10^{15} divisions per coulomb.

In operation, the unit depends on movement of a conducting quartz fiber in an ac electrical field. The fiber is situated between two electrodes charged with alternating current voltages 180 degrees out-of-phase. The fiber reacts to the changing electrical field by oscillating at a rate double the frequency of the applied alternating current.

Because the instrument can measure its own contact potentials, any shift caused by environmental changes can be compensated for in the final measurement.

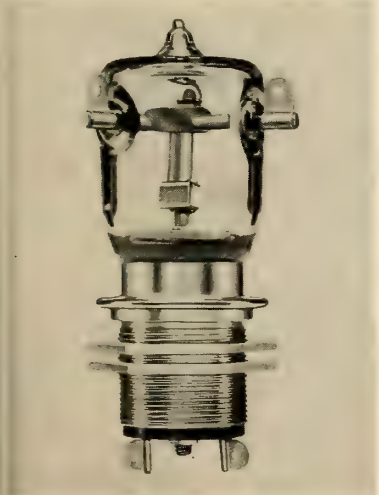
The device is available in two models: one with an input power of 95-125v/190-250v, 20w, 60 cps; one for operation on 95-125v/190-250v, 20w, 50 cps.

Circle No. 168 on Subscriber Service Card

Vacuum Relay

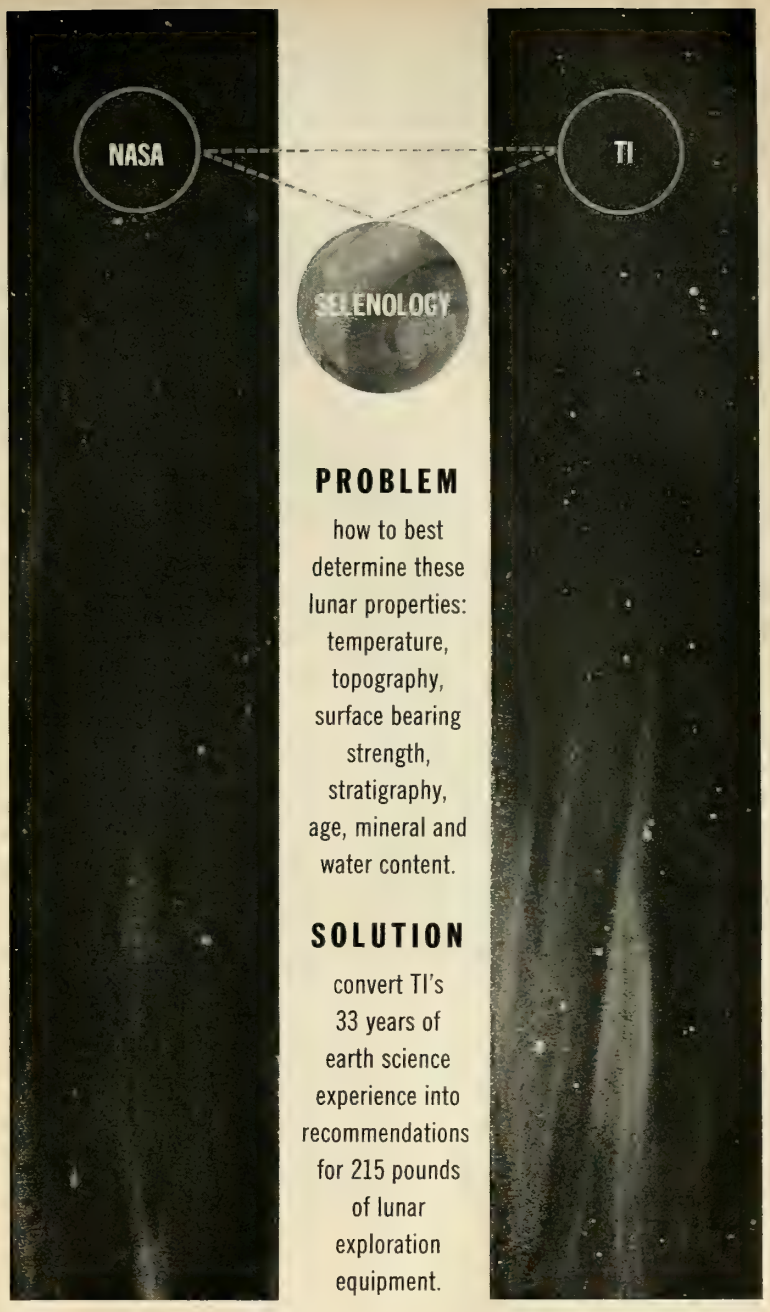
A high-voltage vacuum relay, available in either of three contact forms and three mounting configurations, is being marketed by High Vacuum Electronics, Inc.

The Model H-8 is supplied in SPST, SPDT and DPDT configurations and with solder-flange mountings, threaded-base or three-hole mountings. Operating voltage is 20 kv. Maximum current is



15 amps dc. Maximum switching time is 15 millisecs. Nominal coil voltage is 26.5v dc. Variations of the device can be supplied with operating voltages up to 30 kv (oil).

Circle No. 169 on Subscriber Service Card



NASA's Manned Spacecraft Center selected TI to formulate an optimum series of measurements and experiments which might be made on the lunar surface by Apollo astronauts. **TI** is combining 33 years of geophysical-geological experience with other diverse in-house technologies and management concepts and will recommend to NASA the measurements to be made with the allotted 215 pound exploration package.

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Circle No. 87 on Subscriber Service Card

Breadboarding System

A modular breadboarding system facilitating the checkout of digital logic systems designs has been announced by Roback Corp.

The Facilogic® breadboarding system consists of a pre-wired bench cabinet, an 18-switch panel, power supply, complete set of patchcords and 33 standard plug-in modules, each composed of 1 to 4 basic digital circuits. Matching encapsulated logic modules and standard cards for all modules are available from stock, thus allowing designs to be converted into production systems without long lead times.

All standard circuits are available, including NAND, NOR AND and OR logic. Logic diagrams are screened on the front of the modules and conform to MIL-STD-806B specifications; stacking piggyback leads are available to permit unlimited connections to any module. The modules measure 1.5 x 1.75 x 3 in. Up to 330 modules, or a total of 1,320 circuits, can be accommodated in a 6-ft. relay rack.

Circle No. 170 on Subscriber Service Card

Multicoupler

Electronic Communications, Inc., is producing a 1.5-kw UHF servo-tuned cavity multicoupler with an insertion loss of less than 1 db.

The unit is designated CU-140/GRC and meets MIL-E-16400 requirements. Basic building block is a 1.5-kw tunable filter. The multicoupler contains four of these dual-cavity filters, which can be servo-tuned to any of 3,500 channels in the 225 to 400-mc range. An RF power meter serves as a local monitoring device for each filter.

According to the firm, the high degree of selectivity permits operation at frequency separations as low as 5 mc. Each filter consists of two 10-in. aperture-coupled coaxial cavities resonant at the operating frequency. Other specifications include: an input impedance of 50 ohms (at resonance with output terminated at 50-ohm load); output impedance (to antenna load) of 50 ohms nominal; insertion loss of 1 db maximum; VSWR of 1.5:1 maximum.

Circle No. 171 on Subscriber Service Card

Uncoated Laser Optics

Laser Systems Center of Lear Siegler, Inc., has announced a series of uncoated laser optics, designated as "resonant reflectors." Peak powers over 10^8 watts per square centimeter have been successfully and repeatedly handled by the assemblies, the firm said.

The resonant reflectors are broadband in operation and offer reflectivity from 0.4 to 4 microns. The assemblies of parallel sapphire or quartz plates are available with both a choice of reflector materials and number of elements, thus offering a wide range of reflectance values. Reflectivity peaks are said to be separated by approximately 1 Angstrom.

Circle No. 172 on Subscriber Service Card

Trimming Potentiometers

The Atohm Electronics potentiometer, measuring 0.15 x 0.25 x 0.435 in., is available in a flexible wire lead configuration.

Model 322 is rated at one watt and will operate in temperatures from —65° to 200°C. It is designed to withstand 50 g's constant acceleration, shocks of 50 g's for 11 millisecs. and vibrations of 20 g's from 10 to 2,000 cps.

Other features include a non-abrading wiping surface, insulated metal mandrel embedded in a heat-transfer epoxy and a non-emulsifying lubricant which will not blend with moisture or become gummy.

Circle No. 173 on Subscriber Service Card

Plasma Arc Flow Facility

MHD Research, Inc., has developed the FF-20 plasma arc flow facility, equipped with an 80-kw plasma arc jet heater, which may be operated on either argon or nitrogen.

It is designed for downstream injec-



LS

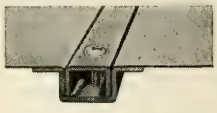
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Circle No. 88 on Subscriber Service Card

tion of oxygen to simulate air at enthalpy levels of up to 10,000 Btu/lb. The arc jet is powered by two 40-kw dc rectifier power supplies which have triple voltage output taps of 80, 160 and 320v open circuit voltage. A 2,000-amp high frequency arc starter is provided as part of the arc circuit.

The gas from the arc jet passes through a Mach 3 supersonic nozzle. Two nozzles are provided with the facility: a conventional nozzle with a circular exit plane of 1 in. dia. and a second nozzle with a rectangular exit plane 0.5 in. x 1.75 in. to provide a "slab" flow of plasma.

The test tank has a diameter of 30 in. and is 36 in. long. It is cooled by tubes on the inside surfaces and contains three rectangular ports, suitable for visual measurements and to bring instrumentation leads into the vacuum test chamber.

Circle No. 174 on Subscriber Service Card

Regulated Current Source

Glentronics, Inc., has developed the Model 21794 current source with a regulation versus temperature of ±0.0025% total over a 100°C range.

For the worst-case combination of line, load and temperature variations, the unit gives absolute current stability within ±0.005% for 60 days. A typical unit of this class includes: input voltage, 115v ac ±10%, 60 cps; output current, 0.2 to 2.0 ma, adjustable; temperature ±0.0025%; temperature range, —30° to 71°C; ripple and noise, 0.005% maximum.

Special units are available within the nominal current range of 0.1 ma to 5 amps, rated output power up to 1,000 watts. Models with dc input power are also available.

Circle No. 175 on Subscriber Service Card

Solid-state Amplifier

A solid-state photon-coupled amplifier with no mutual input-output electrode and which can be used to transfer signals from one circuit to another without electrical contact is available from hp associates.

The optical coupling is accomplished by driving a GaAs injection luminescent diode and channeling the photon radiation generated to a silicon phototransistor. A fiber optic lightpipe is employed for transmission efficiency from the photoemitter to the photodetector.

The Model 4301 can provide dc coupling with microsecond response over potentials of up to 10,000v. Typical electrical characteristics include: signal current transfer ratio of 0.1; signal current transfer cutoff frequency of 1 x 10^6 cps; power dissipation for each device of 100 mw at 25°C. Isolation between input and output exceeds 10^{13} ohms shunted by less than 10^{-14} farads. For larger signal bandwidth applications, another photon coupled isolator is available.

Circle No. 176 on Subscriber Service Card

Charge Amplifier

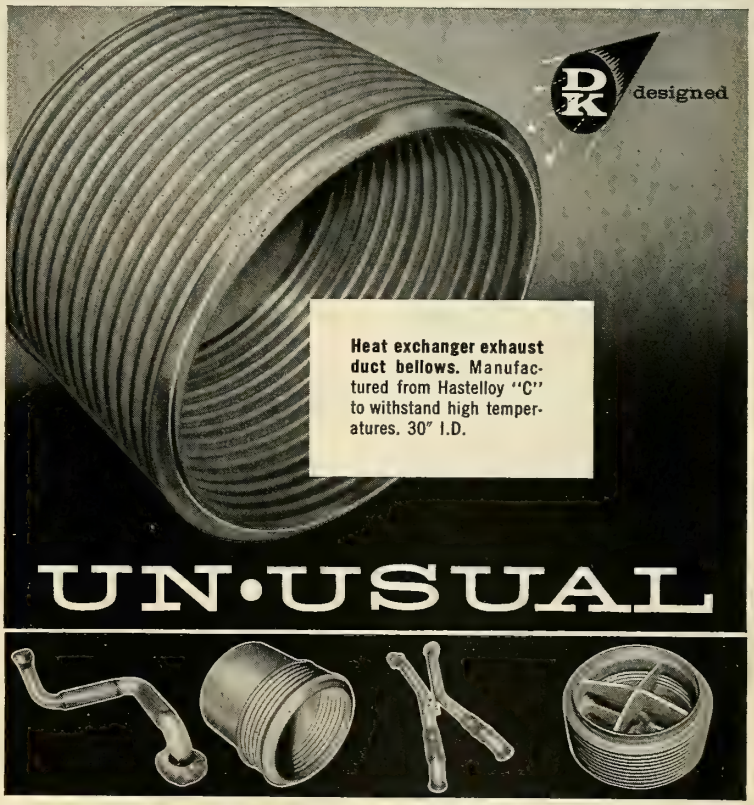
Astrodata, Inc., is marketing a charge amplifier with an input resistance of at least 10,000 megohms and a frequency response approaching dc to 150 kc.

The Model 126-101 has full-scale input ranges in decade steps from 1 to 10,000 psi, g or lbs. The adjustable gage-factor control has ranges of 1 to 11 or 10 to 110 picocoulombs per psi, g or lb. Total full-scale range is from 10 to 110,000 picocoulombs.

The device features two modes of operation. In the "operate" mode, frequency response is within 3 db from 0.3 cps to 150 kc. DC offset drift is less than 0.1% full scale. In the "static calibrate" mode, frequency response is extended nearly to dc. Dynamic calibration at 50% full scale (100-cps square wave) can be performed.

The unit measures 14.8 x 5.7 x 1.4 in.

Circle No. 177 on Subscriber Service Card



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Inco 718 bellows assembly with Inco 718 extensions. This 9" diameter assembly is proof tested at 3000 psig.

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Charge Amplifier

An electrostatic charge amplifier with a frequency response from near-dc to 100,000 cps has been developed by Kistler Instrument Corp.

The solid-state Model 504 has transistorized circuitry, featuring an insulated gate field effect transistor in the input stage. Recovery from extreme overloads of either polarity is said to be instantaneous.

Sensitivity is 1v per g, lb. or psi and input variables can be measured over a range of 0.1 to 50,000. A three-position time constant switch permits static calibration of quartz transducers and dynamic operation of either quartz or ceramic transducer. It may be operated in a 30° to 150°F temperature environment.

Circle No. 178 on Subscriber Service Card

Piezoelectric Accelerometer

Consolidated Electrodynamics Corp. has introduced a piezoelectric accelerometer with a "compliant rod" compression design which mechanically isolates the sensing system from the housing. This provides maximum shielding from the blast of rocket engines and thermal transients.

The Model 4-274 has all-welded construction and is said to eliminate "breathing in" of moisture when operating in severe humidity. When shunted with a recommended value of capacitance (700 picofarads), change in sensitivity over a −100° to 300°F temperature range is typically less than 8%. The 70-kc mounted natural frequency allows a response of ±5% from 2 cps to 12 kc.

Circle No. 179 on Subscriber Service Card

Power Module

Abbott Transistor Laboratories has introduced a series of power modules designed for 60-cycle power. At 120-watts output, the V12/HA12 series provides any required voltage from 5 to 3,650v dc.

Forty-watt models in this group can supply output voltages to 10,400v dc. The modules are hermetically sealed and encapsulated to meet MIL-E-5272C specifications. Operating temperature range is −4° to 160°F. The units feature isolation of outputs and inputs and an adjustment range of 12% from nominal output voltage. Regulation is 0.2% for line variations of 105 to 124v ac; ripple is less than 0.2% RMS.

Circle No. 180 on Subscriber Service Card

Photodiode Laser Detectors

A line of laser detectors has been announced by ITT Industrial Laboratories. The phototubes are high-vacuum photoemissive devices of biplanar geometry with coaxial anode output construction.

The coaxial geometry permits direct coupling of the tube to a 50-ohm coaxial transmission line and allows output current pulses to be transmitted undistorted over relatively long distances, the company maintains.

The series includes tube sizes of 1.25, 2.25 and 5 in., respectively designated F4018, F4000 and F4015. All tubes have opaque photocathodes with an S-1 spectral response.

Circle No. 181 on Subscriber Service Card

Tape Memory System

A tape memory system combining four integral transports and shared electronics in a single self-contained unit is available from Ampex Corp.

The TM-7212 system measures 54 x 56 x 32 in. It contains four TM-7 tape transports, shared read/write electronics



and a logic control unit. The system is designed to read, write and check digital data in IBM computers for mats on magnetic tape. Packing densities are 200, 556 and 800 bits/in.

Circle No. 182 on Subscriber Service Card

Instrumentation Cable

Gulton Industries, Inc., has introduced a shielded four-conductor instrumentation cable, said to substantially reduce "cross-talk" between the excitation voltage and output signals of strain gauges and other bridge circuit devices.

The reduction in coupling is provided by two pairs of twisted leads and an overall shield. Designated C30-C4-Ht, the cable is jacketed with silicon rubber or a variety of plastics. It operates over a temperature range of −75° to 500°F; capacitance is 40 pf/ft. maximum between conductors of the same pair. Capacitance to ground is 50 pf/ft. maximum for each conductor with all others connected to ground.

Circle No. 183 on Subscriber Service Card

Counter-Timer

A solid-state universal counter-timer with all-silicon circuitry has been announced by Computer Measurements Co.

The Models 604 and 605 offer a range of 0 to 2.5 mc for measuring frequency and period. For measurement of frequency ratio, both "A" and "B" channels offer 0 to 2.5 mc ranges. Time interval measurement (Time A → B) range is 10 ms to 10^8 seconds; range for time interval measurement with external clock $\frac{C}{A \rightarrow B}$ is $\frac{100 \text{ cps to } 2.5 \text{ mc}}{\text{Time A} \rightarrow \text{B} \rightarrow 0.4 \text{ ms.}}$ The instruments provide a total count of electrical events (totalize) at a maximum counting rate of 2.5 mc.

CMC offers an option of temperature performance of from −30° to 75°C. Standard guaranteed normal operating temperature range is from −20° to 65°C. Input sensitivity is 0.1v. Selectable attenuation factors are 1/10/100. Crystal stability is ±2 parts in 10^8 per week with an optional oven available for increased temperature stability.

Circle No. 184 on Subscriber Service Card

Instrumentation Amplifier

Systems Engineering Laboratories, Inc., is marketing the Model 9016 wideband dc instrumentation amplifier. Noise referred to input is 5 mv peak-to-peak at 10-kc bandwidth and 1 mv peak-to-peak referred to output.

The unit has a full scale of ±5v output with inputs of ±5, 10, 20, 50 and 100 mv full-scale. Frequency response is 3 db, ±1 db at 10 kc, 24 db/octave, 5-pole linear phase. Gain stability is 0.007%/°C. Common mode rejection is 180 db at dc and 120 db at 60 cps with 1,000 ohms unbalance. Offset adjustment for offsetting input up to 10% of full scale is included.

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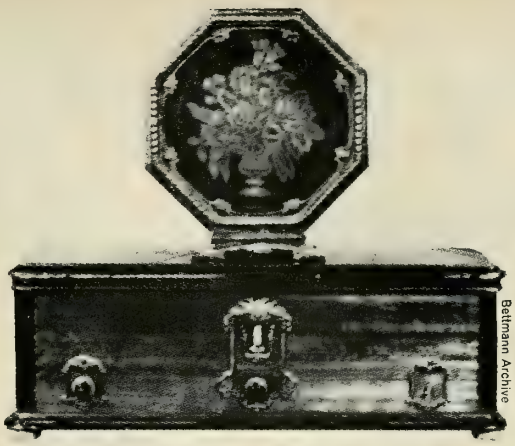
Laser Glass

A laser glass based on ytterbium doping has been developed by Eastman Kodak Co.

The glass has a fluorescence time constant of 1,200 mc for output in the multi-megawatt range through Q-switch operation. The ytterbium emission wavelength is 1.02 microns, compared to the 1.06-micron emission of neodymium, used in Kodak's original laser glass.

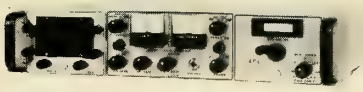
The glass has a borax matrix and Kodak engineers believe beam divergence can be kept under 2 milliradians when used in well designed cavities. Typical threshold for a 6 x 0.25-in. rod of the ytterbium doping is quoted at 250 joules. Laser actions occurs below 200°K.

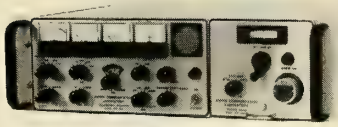
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TR-104 Telemetry Receiving System

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☐ To see this ACL modular concept in action, consider first the SR-209 Surveillance Receiving System. Only 3½" high, it provides AM, FM, CW, and Pulse reception from 30 to 2000 mc with 5 plug-in tuning heads . . . offering 9 IF channels with matching FM and AM demodulators, a plug-in signal display unit, and a plug-in, rechargeable, nickel-cadmium battery pack. Battery-powered, the SR-209 becomes completely self-sufficient.

☐ Or take another member of the family—the TR-104 Telemetry Receiving System. This one receives all standard IRIG signal formats in the 55-2300 mc range with 8 plug-in RF heads. Ten IF bandwidths are available (10 kc to 3.3 mc) and 4 IF bandwidth amplifiers and matching demodulators may be installed at one time, switchable from the front panel. Just 5¼" high, the unit requires a maximum of 35 watts and may be battery-operated in the field.

☐ Noise figures, IF and image rejection, sensitivity, stability and all other specs for these receivers are as impressive as their wide range of features.

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Needle Valve

A line of needle valves featuring a micrometer handle that permits exact setting of the desired micro-flow rate has



been introduced by Circle Seal Products Co., Inc.

According to the firm, a guide/seat arrangement maintains pin-point seat concentricity with the needle at all times. Metering is made possible by an 0.02-in-dia. orifice, which together with the micrometer-calibrated handle permits metering of C_V0.008 full open or less than C_V of 0.0003 when barely cracked open.

The MV90 Series valves are Teflon-packed below the threads to protect against contamination by corrosive fluids. Operating pressure range is 0 to 3,000 psi.

Circle No. 187 on Subscriber Service Card

Moving Target Indicator

A modular moving target indicator (MTI) test set has been developed by the Surface Div. of Westinghouse Defense and Space Center.

Designed for use with fixed, tactical or shipboard radars, the unit measures sub-clutter visibility of a moving target indicator at either the radar's transmitted or intermediate frequency. The set uses interchangeable frequency converters to monitor frequencies from ultra-high through S-band.

The transistorized test set is comprised of modules for ease of maintenance and can be removed from its transit case for installation at fixed sites or repackaged to fit special requirements.

Circle No. 188 on Subscriber Service Card

PPM-Focused TWT

A series of X-band, PPM-focused traveling wave tubes is being marketed by General Electric Co.'s Tube Dept.

Noise figures of 8 db are available for four narrowband types covering the

7 to 10-gc frequency range. Three broadband versions offer power output greater than 10 mw over the 7 to 11-gc range and exceeding 5 mw over the 8 to 12-gc range. Small signal gain is greater than 30 db over the entire band.

The metal and ceramic tubes weigh 5.5 lbs., measure 10.7 in. and can be mounted in any position. The tubes have been tested to withstand shock of 30 g's for 11 ms and 15-g vibration to 2,000 cps. Other tests have confirmed successful operation at 100,000 ft. altitude and at an ambient temperature range from −60° to 92°C, GE said.

Circle No. 189 on Subscriber Service Card

Coaxial Isolators

Two high ratio coaxial isolators are being marketed by E&M Laboratories.

The Model LS10JI covers the frequency range of 1.7 to 2.4 gc with 60 db minimum isolation. Insertion loss is 1.0 db maximum; maximum VSWR is 1.20.

The Model C35JI operates in the 5.4 to 5.9-gc range with 60-db minimum isolation. Insertion loss is 0.8 db maximum; VSWR is 1.20 maximum.

Circle No. 190 on Subscriber Service Card

Oscilloscope Camera

The Model C-27 oscilloscope camera with lift-on mounting and swing-away hinging has been announced by Tektronix, Inc.

The back rotates for vertical or horizontal positioning and slides into nine



detent positions for multiple-exposure photography. An f/1.9, 1:0.85 lens is supplied with the unit. Available accessories include a 35-mm attachment with automatic advance, which allows uninterrupted rapid-sequence exposures of up to 4 per second, and a shutter actuator permitting electrically-triggered exposures.

Circle No. 191 on Subscriber Service Card

Directional Coupler

A series of precision waveguide directional couplers with a ±0.2-db coupling characteristic is available from Waveline, Inc.

Fifteen standard versions provide coupling values of 10, 20 or 30 db over a frequency range of 3.95 to 18.0 gc. Specifications include: average coupling, standard ±0.3 db; coupling sensitivity, ±0.2 db maximum; minimum directivity, 40 db; main line VSWR, 1.10 maximum; secondary line VSWR, 1.20 maximum.

Circle No. 192 on Subscriber Service Card

Helium Dewars

A group of helium research dewars, designed with rotatable windows on the bottom, has been announced by Hofman Laboratories.

Applicable for optical maser research, low-temperature observation and fluorescence measurement, the Model HLRB is designed with an interconnected, super-insulated vacuum of 10^{-9} mm Hg for nitrogen and helium reservoirs. Side pump-out tubes are supplied on the helium reservoir for attachment to recovery systems or for experiments down to 1.2° K. The nitrogen reservoir acts as an insulating medium for liquid helium; minimum heat leak is assured by a helium mass spectrometer leak test of less than 10^{-6} micron cubic feet per hour.

The outer bottom of the dewar may be rotated 360 degrees relative to the sample holder while under full vacuum. Six models are available, in helium capacities from 1.5 to 4 liters and with 2 to 4 windows.

Circle No. 193 on Subscriber Service Card

Chart Recorder

Nelco Instruments Div. of Datapulse, Inc., has developed a 10-mv, 5-in. chart recorder with 0.5-sec. response time.

The Model JY100A has 0.5% accuracy with dual chart drive and capillary pen. Zero location may be positioned, by panel control, any place on chart or up to ±25% off-scale. Sensitivity is 0.25% full span. Units are provided with floating input with separate chassis ground. Measurements may be made at levels up to 150v off ground.

Customers may select a single- or dual-speed unit with choice of one or two of 16 chart speeds. Mercury cell and zener reference systems, special power, reversed polarity, event markers and special indicating scales are available. Dimensions are 9 x 6.25 x 11 in. (rack-mounted, 12.25 x 19 in.).

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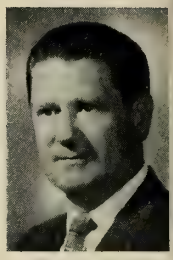
names in the news



NIMITZ



HILL



WALDSCHMITT

Chester W. Nimitz, Jr.: Elected president and chief executive officer of the Perkin-Elmer Corp., Norwalk, Conn. He will succeed Robert E. Lewis on Jan. 1.

Marion E. Hines: Elected vice president of Microwave Associates, Inc., Burlington, Mass. He will continue as director of special products research.

Frederick J. Anderson: Appointed manager of the *Minuteman* program for Sylvania Electronic Systems, a division of Sylvania Electric Products Inc. He will direct all phases of *Minuteman* work Sylvania is performing for the Air Force.

Louis A. deRosa: Appointed technical director of the U.S. Defense and Space Group of International Telephone & Telegraph Corp., New York City. He will also represent ITT in all technical activities in the company's work with various U.S. government agencies.

John J. Coleman: Joined Planning Research Corp., Los Angeles, as senior associate in the firm's Systems Engineering Division. He will plan, design and evaluate aerospace and industrial systems.

Clarence S. Small: Promoted to production manager for the advanced programs division of the G. T. Schjeldahl Co., North field, Minn. Among the programs he will be responsible for are active thin film, passive thin film, balloons, missile hardware and communications satellites.

Cory L. Gray and Robert K. Otnes: Recently joined Measurement Analysis Corp., Los Angeles.

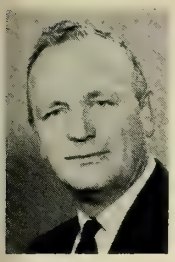
Cyrus R. McAllister: Promoted to research director in the Western Operations Office of Booz, Allen Applied Research Inc., Los Angeles. He will direct projects in areas of applied mathematics and systems effectiveness.

Malcolm H. Barnes: Appointed general manager of the newly created electronics department of Union Carbide Corporation's Linde Division, New York City.

Dewey Childs: Named test supervisor for the *SA-9 Saturn I* test flight now expected to take place early next year at Kennedy Space Center in Florida. Other appointments made by KSC for the *SA-9* shot include **John Twigg,** launch vehicle test conductor; **C. F. Henschel,** assistant test conductor for the launch vehicle and the S-IV stage engineer; **N. M. Carlson,** assistant (trainee) S-I stage engineer; **M. J. Peacock** of Chrysler, S-I operations engineer; **John Churchwell** of Douglas, S-IV stage engineer with **W. D. Guest** as his assistant, and **F. G. Bryan,** stage engineer for the *Pegasus* micrometeoroid satellite.

Morris Barnhart: Has gone to Paris to open a technical and sales support office of Telemetrics, Inc., Santa Ana, Calif. He is assistant chief engineer for the company.

William MacCrehan, Jr.: Appointed manager of quality and reliability of the molecular electronics division of Westinghouse Electric Corp., Pittsburgh.



SMALL



COLEMAN



WILLS

John J. Guerrera and William J. Moreland: Joined WESCON's eight man volunteer board of directors. Guerrera is president of Guide Manufacturing Co., North Hollywood, Calif.; Moreland is general manager of the Conrac Division of Giannini Controls.

Conrad J. Rauch: Promoted to vice president and general manager of Cryonetics Corp., Burlington, Mass. He will be responsible also for the management of the solid state department.

David A. Hill: Joined the Vitro West Orange Laboratory as chief physicist, Vitro Corporation of America. He was formerly with the Massachusetts Institute of Technology, Laboratory for Nuclear Sciences.

Mervin Stern: Appointed president of the Aerospace Systems Division of General Precision Aerospace Group, Little Falls, N.J. He was formerly deputy director of Defense Research and Engineering in the Department of Defense. Also named to new positions were **Herman R. Shuart,** vice president-aerospace group; and **Joseph B. Heimann,** president-Kearfott Division.

Three key staff members have joined the Office of Science and Technology in the Executive Office of the President. **Dr. Charles V. Kidd** has been named Executive Secretary of the Federal Council for Science and Technology. **William T. Knox** has assumed responsibility for stimulating development of more effective scientific and technical information systems. **Ray K. Linsley, Jr.,** will be responsible for OST's activities in water resources research.

Joseph A. Waldschmitt: Elected a corporate vice president of Northrop Corporation, Beverly Hills, Calif. He is also president of Page Communications, a wholly-owned subsidiary.

Eugene Miller: Assigned to the dual post of assistant technical director and director of advanced design at Lockheed Propulsion Co., Redlands, Calif.

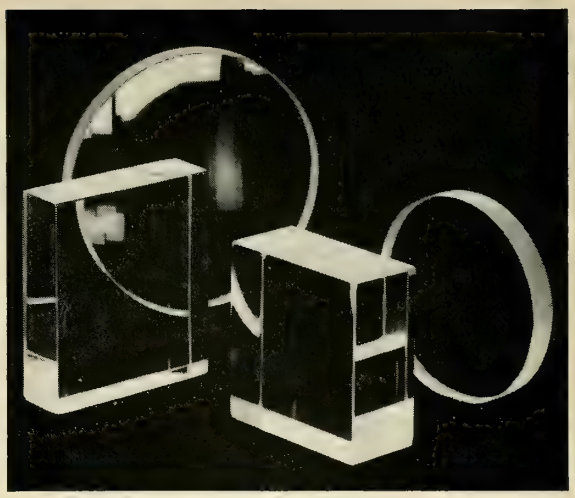
J. L. Atwood: Elected Chairman of the Board of Governors of the Aerospace Industries Association. Succeeding Donald W. Douglas, Jr., he is also board chairman and president of North American Aviation, Inc.

Ernest Greenwood: Appointed executive vice president of the Norden division of United Aircraft Corp., Norwalk, Conn. He has been divisional vice president-operations since 1962. Also named was **William Scott,** formerly of General Electric Co., as operations manager.

Charles P. Morrow: Appointed a field engineering representative of the Western Regional Office, Consolidated Systems Corp., Albuquerque, N.M.

Frederick J. Wills, Jr.: Promoted to operation manager of Raytheon Company's Semiconductor Operation, Mountain View, Calif. He succeeds Clyde R. Rockwood, who resigned.

Herbert R. Montague: Named manager of the electronic gaging department of Schaevitz Engineering, Pennsauken, N.J.



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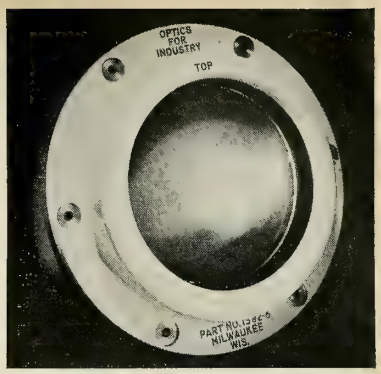
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The Next Steps

THE ADMINISTRATION now is confronted by budgetary decisions on the many and expensive projects which will make up the U.S. space program after the initial manned lunar landing.

These decisions are as important in their own right as the initial one to go ahead with Project *Apollo*.

The fact that these options are arising at this time does not mean that we can regard the lunar landing as accomplished. But it does mean that wise action concerning the forthcoming budget will avert the situation that existed when Project *Mercury* was undertaken without prompt consideration of what the follow-on program should be.

We are reaping the fruits of that administrative failure in a lag of nearly two years between the last one-man *Mecury* flight and the first two-man *Gemini* flight.

To prevent a recurrence, the Administration must now begin to fund some of the programs which will follow the *Apollo* landing. The long leadtime of major space projects and the necessity of careful program definition in unknown areas make this a must.

This will require an educated appraisal of the Fiscal Year 1966 National Aeronautics and Space Administration budget by the President, the Bureau of Budget and the Congress.

NASA is seeking a budget for FY '66 of $5.5 to 5.6 billion. This is intended to carry *Apollo* through a critical year as well as initiate work on projects to follow.

Before examining some of the alternatives for the post-lunar landing period, the situation regarding *Apollo* itself deserves special consideration. Manned *Gemini* flights are to begin during calendar 1965, while *Apollo* hardware is entering a crucial test phase. The program thus is moving into a period when it undoubtedly will encounter some as yet unforeseen problems.

The dilemma for project officials and for NASA Administrator James Webb is how to convince the Administration that funds are needed to solve these problems—when by the very nature of the beast they cannot say what the problems are.

It will require a considerable display of wisdom at the White House and on the Hill to accept the need for funding of something as intangible as this. Yet the success of the program may depend upon it.

To falter at this point in support of *Apollo* is to endanger all that has gone before. Despite some problems, the project is moving well and still holds strong promise of a lunar landing before the end of the decade, together with the possibility of beating the Russians to the Moon.

It is to be hoped that President Johnson, so closely identified with the space program from its inception, will want to assure that the lunar landing takes place during his probable term of office. To go down in history as the man holding the nation's highest office when the human race takes its first step off the Earth is no mean goal. This is within the grasp of Lyndon Johnson. His Administration's actions in regard to the forthcoming NASA budget will be a major factor in determining whether the possibility of Americans winning those laurels becomes a reality.

Involved, of course, is considerably more than the President's ego. It is almost impossible to imagine today the impact on the world of that first landing on the Moon. If it is a Russian achievement, it will be a signal to the nations of the world that the Soviet Union has passed the United States as the leading technological power, with an accompanying political effect that will echo down through the centuries. There is not much honor in being second horse in a two-horse race.

BUT THE SPACE PROGRAM does not end with a lunar landing. That is why it is also necessary for the Administration to face in its current budget meetings the need for decisions on post-*Apollo* programs.

Of these, the most immediate is that concerning the *Apollo-X* project, which foreshadows the use of the basic *Apollo* capsule in a system for scientific exploration in Earth-orbital and lunar-orbital missions. NASA has made the decision to move *Apollo-X* into the Program Definition Phase in the coming year. Whether the program will also undertake funding of long-leadtime hardware items will depend on Administration approval of a $5.6-billion budget with $50 to $75 million for *Apollo-X*. A lower budget figure could mean a flight delay of as much as a year.

The *Apollo-X* schedule as now drawn up calls for first flight in late 1968 or early 1969, with flights into 1971. The manned spacecraft program then would shift to a six to 12-man space station capable of staying in orbit for a year or more. Funding for pre-program definition studies of space-station concepts is being asked in the new budget, with PDP and long-leadtime funding anticipated in FY '67.

The space agency also is undertaking studies of the lunar exploration or lunar basing which would be a logical follow-on to the initial landing. It is anxious to open the path to a manned Mars landing with an unmanned *Voyager* mission to that planet in 1969.

Although fulfillment in all of these projects—at a total cost of billions of dollars—is many years away, it is necessary to provide some funding for them in the forthcoming budget if the nation is to have a well-based space program in the years ahead.

The $5.6-billion budget, to continue *Apollo* on a sound basis and to initiate starts on new projects, anticipates continuation of space funding at least at this level for the remainder of the decade. It is an investment this nation easily can afford if it has the will to win and retain pre-eminence in space.

William J. Coughlin

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Engineer-astronauts board a NASA Gemini Spacecraft during tests in McDonnell's new 30-foot, man-rated, high vacuum/thermal chamber. This chamber (built by Chicago Bridge & Iron Co.) permits testing of production spacecraft in simulated environments as far out as 236 nautical miles. It is the largest of 14 altitude chambers now in operation in McDonnell's Space Center.

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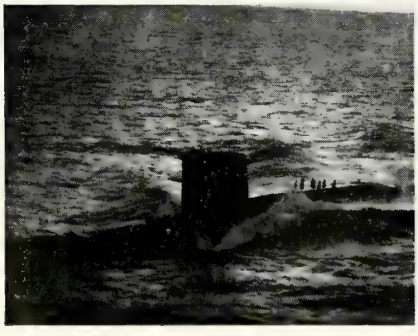
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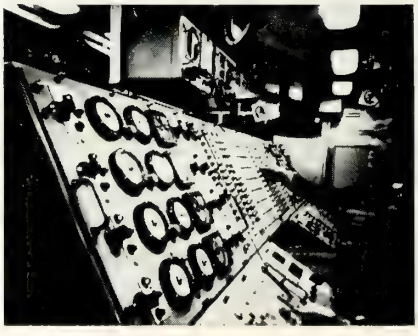
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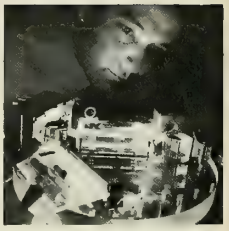
Printed at Judd & Detweiler, Inc., Washington, D.C. Second class postage paid at Washington, D.C.

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Subscription rates: U.S. and Possessions, Canada, and Pan American Postal Union Nations: 1 year, $5.00, 2 years $8.00, 3 years $10.00. All other foreign: 1 year $15.00, 2 years $25.00, 3 years $35.00. Air freight to Europe: 1 year $20.00, 2 years $30.00, 3 years $40.00. Single copy prices: regular issues 50 cents each; special issues $1.00 each. Subscriptions are solicited only from persons with identifiable commercial or professional interests in the missile/space industry. Subscription orders and changes of address should be referred to Circulation Fulfillment Mgr., Missiles and Rockets, 1001 Vermont Ave., N.W., Washington, D.C. 20005. Allow 4 weeks for change to become effective and enclose recent address label if possible.

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THE COVER



Miniature laser integrating gyro (LIG) is tested in Honeywell Systems & Research Div. lab. It covers less than two tenths of a square foot and weighs less than 8 lbs. One of the division's development programs is to produce a practical LIG with inertial grade performance.

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We knew what we wanted

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Was it possible, we asked, to produce a complete line of magnetic tape that would enable *every* instrumentation recorder to deliver its full potential?

As the leading manufacturer of data recorders, CEC wanted to know. We were well aware of the existing problems, particularly the costly trial and error in tape selection.

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It also illustrates why CEC maintains a network of 22 sales and service offices throughout the nation. To expedite application engineering. To familiarize customer personnel with new advances in instrumentation. To search for more efficient and economical ways to "do the job."

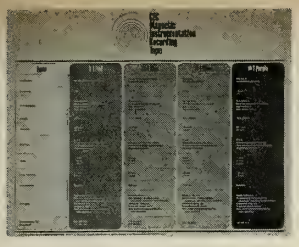


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In addition, here are some other significant facts you will discover about CEC Magnetic Tape:

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letters

High Price of Silence

To the Editor:

Reference your editorial, "The High Price of Silence," M/R, Nov. 23.

To your article I again say "amen." Might I suggest that a very lucrative field for the General Accounting Office could be found in Massachusetts, as described in December's *Readers Digest* and entitled "Highway Robbery in Massachusetts."

Miles Kracman
Mishawaka, Ind.

To the Editor:

This letter is to commend your Nov. 23 editorial and suggest that you have pointed out only one of many situations in which these tactics are utilized. This situation probably exists in many Federal agencies and, as you indicated, the firms and/or individuals lack the moral courage to resist the apparently indomitable force of the Federal government.

Acceptance of these edicts, right or wrong, can be construed as evidence of laxity or improper conduct. (This is not to say, of course, that in some situations these conditions are not found.) One could easily be led to believe this results from a government manipulating individual lives with the strings of the purse.

J. W. Brasher
Pascagoula, Miss.

Civil Service Guide

To the Editor:

On Nov. 5, Mr. Joseph Young, a Washington correspondent, reported that the President was dissatisfied with many top-level Civil Service management employees. They were mediocre, he charged, and should be replaced by outstanding men, now that government salaries were practically on a par with those of private industry.

However encouraging this news item may appear to some, experienced observers are skeptical, and the undersigned still recommends the following ten steps to anyone aspiring to a top management job in Civil Service:

1. On your application omit any academic degrees you may be holding—they immediately make you suspect to a top-level non-degreed supervisor.
2. During any interview belittle and downgrade professionals of any type: accountants, engineers, economists. Praise long government service, especially in an office handling paper work.
3. Once on the job, avoid meaningful work. Appear busy, call conferences, call meetings, talk loudly and with assurance, write incomprehensible English.
4. To advance, find out who is an avid golfer in the echelon above yours. Play the same course, meet the follow often, admire his game, let him know that you are his man.
5. Promise promotions to those below you, especially if they agree to support you and heckle your enemies.
6. Discredit all able and conscientious workers. They obviously are of no use to you. They are only interested in doing a good job.
7. Smile at secretaries; joke and appear attentive. Whatever their age or looks, they may be useful someday by "accidentally" opening sealed reports or mail meant for a potential boat-rocker.
8. Lose, misplace or "edit" unfavorable reports from subordinates, so that your record is kept exemplary.
9. Promote and assign to training slots only people loyal to you, regardless of their lack of qualifications.
10. Now that you have a good organization, run a tight ship. Be ruthless. Soon you'll be at the top.

Henry Albert
Burbank, Calif.

ASW Tracker Planes

To the Editor:

A copy of your Sept. 21 issue has just reached me. May I commend your Special Report: Anti-Submarine Warfare as being a stimulating and comprehensive study of a most interesting subject.

No doubt someone has called your attention to the error on page 26 with regard to the S-2 Tracker aircraft. Without trying to explain how it happened, when the S2F1S1, S2F3, and S2F3S aircraft were redesignated under the "new" system they got out of sequence. What was the S2F3S aircraft is actually the latest model and is accurately described in your summary as the "F" model. Take my word for it, the aircraft described is actually the S2E. The "F" model refers to the old S2F1S1 aircraft.

I feel relatively qualified on this score since, as commanding officer of Air Anti-Submarine Squadron Twenty-Eight, I have had the pleasure of flying both the "F" and the newer "E." Currently we are deployed in the Mediterranean on board the USS Wasp (CVS-18) and are a part of the only air group on the East Coast to fly the new "E." It *is* a very good aircraft.

Jack M. Stevens
Commander, U.S. Navy

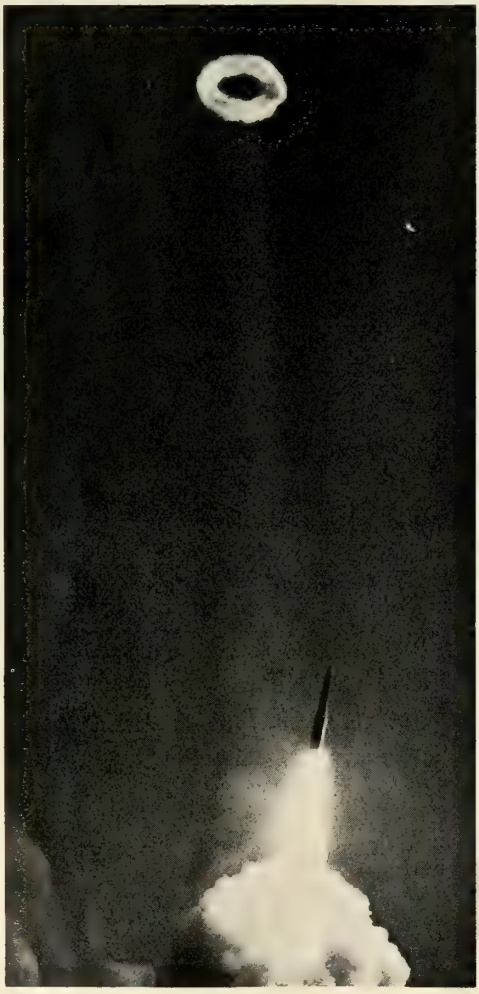
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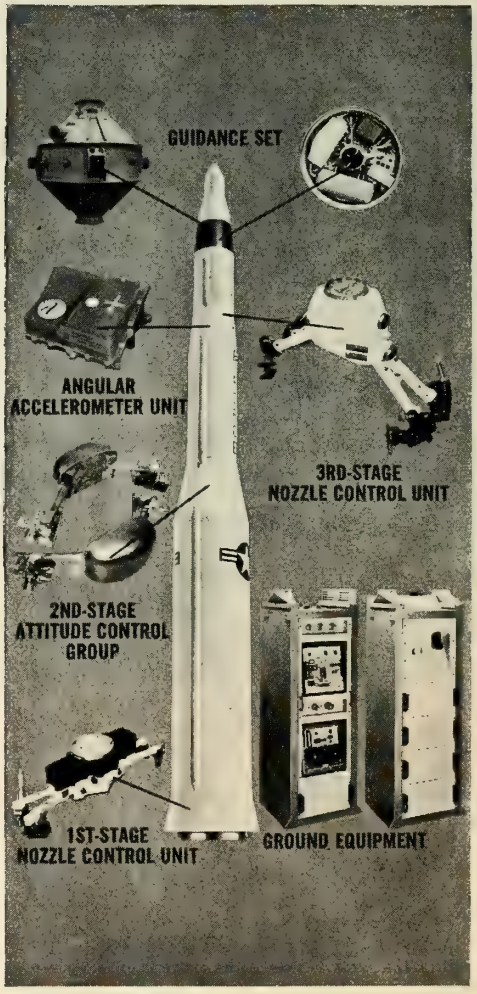
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The Countdown

WASHINGTON

Voyager RFP's Expected in January

Requests for proposals for the program definition phase of the *Voyager* spacecraft program now are expected about Jan. 1. A meeting between space science officials and NASA Associate Administrator Dr. Robert C. Seamans, Jr., will be held this week to wrap up details. Two to four firms will be selected for first phase, with the prime development contractor to be named by spring of 1966. First contract probably will cover spacecraft for both the 1971 and 1973 launch windows. Officials still are hopeful they will be able to make a flight test of the spacecraft bus in 1969.

GAO Undertakes Expense Probe on Its Own

General Accounting Office has disclosed that its probe of industry expense accounts (M/R, Nov. 23, p. 9; Nov. 30, p. 20) was undertaken at its own initiative, not at the request of a Congressional committee. GAO sources say, however, that the investigation was an outgrowth of its probe of contractor recreation and welfare expenses, undertaken last spring for Rep. Porter Hardy's investigating subcommittee of the House Armed Services Committee.

Brighter Future Seen for AEC Projects

Atomic Energy Commissioner James T. Ramey says chances now are better that AEC projects will be carried from research and development through full developmental testing. AEC long has been unhappy with the setup under which programs such as the *Pluto* nuclear ramjet have been killed before flight testing due to a lack of specific military requirements. Ramey says a "useful exchange" of correspondence between the White House and the Congressional Joint Committee on Atomic Energy may change this.

Big Space Role Seen for Reactors

Atomic Energy Commission chairman Dr. Glen Seaborg told a San Francisco conference last week that nuclear reactors will be fully integrated into the U.S. space program by 1980 as primary propulsion for post-*Apollo* space vehicles on long manned and unmanned missions to the planets. Unmanned scientific missions to Mars, Venus and Mercury with nuclear units aboard will be almost commonplace by 1980, he predicted.

TAC Recommendation Due on TMRBM

Recommendations from Tactical Air Command on the *Transportable Mid Range Ballistic Missile* are due at the Pentagon. TAC is expected to give tentative approval to the idea, with some modifications and reservations.

Bisplinghoff Resignation Is Expected

Dr. Raymond Bisplinghoff is expected to resign his NASA position as deputy associate administrator for advanced research and technology in the near future. When he accepted the position, it was with the understanding he would remain for only two years—a tour now near its end. His successor is expected to be his current deputy, Dr. A. J. Eggers.

Explorer 25 Still Awaits Turn-on

Explorer 25, the 90-lb. satellite to measure bombardment of energetic particles from space which was launched Nov. 21, is not yet returning data. Its experiments cannot be turned on until the satellite stops spinning. Program manager Raymond Miller expects that to occur this week.

INDUSTRY

New Missile Guidance Under Study

A low-cost inertial guidance system for a range of tactical missiles is being funded as an in-house development by Lockheed Missiles and Space Co., in conjunction with Lear Siegler Inc. and AC Spark Plug. Acceleration tests of a working model of the package are scheduled on the 35,000-ft. missile test track at Holloman AFB, N.M., in January and February. System is designed for missiles in the 40-50-n. mi. range. Unit cost is predicted at between $10,000 and $20,-000, depending on accuracy requirements, which could be designed from 50 ft. to 240 ft. Total weight: 37 lbs.

Grumman Interested in Arma Facility

Grumman Aircraft and Engineering Corp. has been in negotiation with the Arma division of American Bosch Arma Corp. for a sub-lease of Arma's 500,000-sq.-ft. facility in Garden City, N.Y. Grumman hopes to move in about Jan. 1.

Improved Aerospace Profits Are Forecast

The New York investment firm of Eastman Dillon, Union Securities & Co. predicts in its current review of the industry that the changing pattern of Defense Dept. procurement policies will bring improved profit margins and contract stability. But the report warns investors that selectivity is necessary, since the DOD program is expected to favor large, well-managed companies with broad-based technical capability.

ESD Wants More Firms To Bid

Procurement officials at Air Force's Electronic Systems Division say they generally are disappointed at the lack of competition on the division's Requests for Proposals. "We would like to have more firms making bids for our contracts," one officer told COUNTDOWN.

DOD To Open Consolidated Security Shop

Defense Industrial Security Clearance Office, to handle security clearances for military contractors, will be opened next March at the Defense Construction Supply Center, Columbus, Ohio. The office will consolidate functions now handled at more than 100 locations.

TRW Wins SGLS Bid

Air Force has awarded a $9-million contract to TRW Space Technology Laboratories in its long-range effort to standardize electronic equipment packages for its satellite programs. Contract is for production during the next two years of a space ground link subsystem (SGLS) consisting of eight vehicle packages and a demonstration ground station.

INTERNATIONAL

French Plan Rocket Test Track

A rocket test track similar to one at the Naval Ordnance Test Center, China Lake, Calif., is to be erected by the French government at its new R&D test center. Maj. Jacques Bergez of the French Ministry of Defense toured NOTS track facilities last week.

ASMS Request Cancelled

The Navy has decided to cancel its FY 1966 funding request for production of the *Advanced Surface Missile System.*

Pentagon speculation is that the decision to delay the money request stems from development problems with the system, which is designed as a successor to the 3-T, *Terrier, Tartar and Talos,* family of shipboard missiles in the 1970's.

Weight and size complexities are said to be the stumbling blocks that must be overcome to permit fully funded production.

Solution of these problems within the next few months could result in a Navy decision to seek a supplemental appropriation during the coming session of Congress.

Shots of the Week

Mariner IV, equipped with a new magnesium-thorium shroud, was launched from Cape Kennedy Nov. 28, and the middle of last week was 324-million-mile trip to Mars. (See p. 12).

- The Soviet's *Zond 2* Mars probe was launched Nov. 30, from a vehicle in Earth orbit according to the Soviet news agency Tass. Tass admitted the craft was in trouble soon after its release from the vehicle, however, with its power supply running approximately 50% below the wattage expected.
- The Air Force on Dec. 1 launched an *ABRES* ballistic re-entry system nose cone 5,000 mi. down the Western Test Range from Vandenberg AFB, Calif.
- The Air Force *Athena* research missile was intentionally destroyed in flight within a pre-planned safety zone over southeastern Utah Nov. 27 when it appeared to range officials that high winds might force the vehicle off its course. The vehicle apparently functioned satisfactorily from launch to the time of abort. The four-stage missile performed perfectly in its first full-stage mission with a full payload Nov. 6.
- The Navy successfully launched a *Polaris A-3* missile from the USS Stonewall Jackson on Dec. 2. The 2,000-mi. shot was the first in a series of training launches for the sub.
- The Army's *Mauler* air defense missile underwent a successful test firing against a target drone last week at the White Sands Missile Range. The General Dynamics/Pomona missile is in the flight test program phase.

Douglas Hits 'Contracting Out'

Douglas Aircraft Co. president Donald W. Douglas, Jr., has publicly criticized the Dept. of Defense policy of awarding production contracts to firms other than those responsible for the research and development phase.

Douglas told a New York City meeting of the American Ordnance Assn.: "No longer are we in industry thought of as producers of armament but rather as producers of technology." But, Douglas pointed out, an important obstacle in the path of continued advance in the research field is the low profit margin—less than 3%—on which the aerospace industry operates.

To this is now added the possibility that lucrative production contracts can be lost at the last minute to other companies and "the opportunity to make a profit on production which helps finance . . . R&D is completely lost," Douglas said.

He said he doubted that the practice of awarding production contracts to non-developers saved money anyway because a firm's lack of experience often results in unexpected costs.

Although industry has privately expressed strong reservations about the advisability of "contracting out" production, Douglas is the first top industry spokesman to speak out against the policy in public.

Bioinstrumentation RFP's In

Bids have been received by NASA's Manned Spacecraft Center for the *Apollo* bioinstrumentation contract, which will cover design, development, fabrication, testing and quality assurance to satisfy both ground test support and flight test requirements.

Some 86 companies were asked to bid on the project. The instrumentation is to provide information on such parameters as strength and rate of heartbeat, respiration rate and approximate depth, body temperature, and blood pressure.

Two kinds of configurations must be supplied. The first, applicable to ground tests and flight simulations, must include two electrocardiograph signal conditioners, an impedance pneumograph signal conditioner, temperature signal conditioner, temperature probe, blood pressure measuring system with signal conditioner and microphone, power converter, and wiring harness. Specific weight limitations are given.

The second aspect will provide flight devices, including also signal conditioners for electrocardiograph and impedance pneumograph, a power converter and 500 electrodes and non-toxic electrode paste which can be applied for one year or more, and a wiring harness.

DOD Considering ASPR Changes

DOD has sent letters to industry seeking comments on proposed changes to the Armed Services Procurement Regulations on the breakout of systems components and the costing of intra-company transfer of materials.

Proposed wording of the breakout proposal is: "If a weapon system or other item of major equipment cannot be procured on the basis of effective price competition, it is DOD policy to break out components that are not being procured competitively by the end item contractor whenever such breakout (1) will result in overall savings to the government and (2) will not jeopardize the satisfactory performance and timely delivery of the end item."

Proposed costing procedures relating to intra-company transfers of materials specify that "allowance for all materials produced by the contractor or by any division, subsidiary or affiliate of the contractor under common control (referred to as the 'seller') shall be in accordance with a policy which calls for such materials to be priced "not to exceed the lesser of the current market price or the seller's current sales price to its most favored customer for a like quantity of the item."

Russia Gets Tiros Weather Data

Tiros satellite pictures are being transmitted over the new "cold" line established between Moscow and the U.S. Weather Bureau in Washington, D.C.

The cable circuit, laid by Radio Corp. of America, is the result of a bilateral agreement made two years ago between the USSR Academy of Science and NASA. It will permit alternate use of facsimile, data, voice and telegraph communications. The line runs through Frankfurt, London, Berlin and Warsaw.

S-IVB Fired at Full-Power

First full-power static firing of the hydrogen-fueled *Saturn* S-IVB stage was achieved at the Douglas Missile and Space Systems Div., Sacramento, Calif., Test Center.

The firing, in which the J-2 engines were operated at full 200,000-lb. thrust, lasted for 10 seconds as planned. It also marked the first use of the new test complex Beta, consisting of two 150-ft.-high steel and concrete stands capable of holding down rockets with more than a million pounds thrust, which was built for the S-IVB program.

The next phase of the test program will be to work up through a series of 20-second, 50-second and 150-second firings to the first full-duration, full-power test, which will last 480 seconds. At least six tests are scheduled over the next few months to provide operating data for Douglas engineers and to evaluate the design of the stage, ground support equipment, test facilities and operating procedures.

Primary objectives of the 10-second test were to achieve engine start, advance to full thrust, stabilize mainstage operation for the duration, and shut down on schedule.

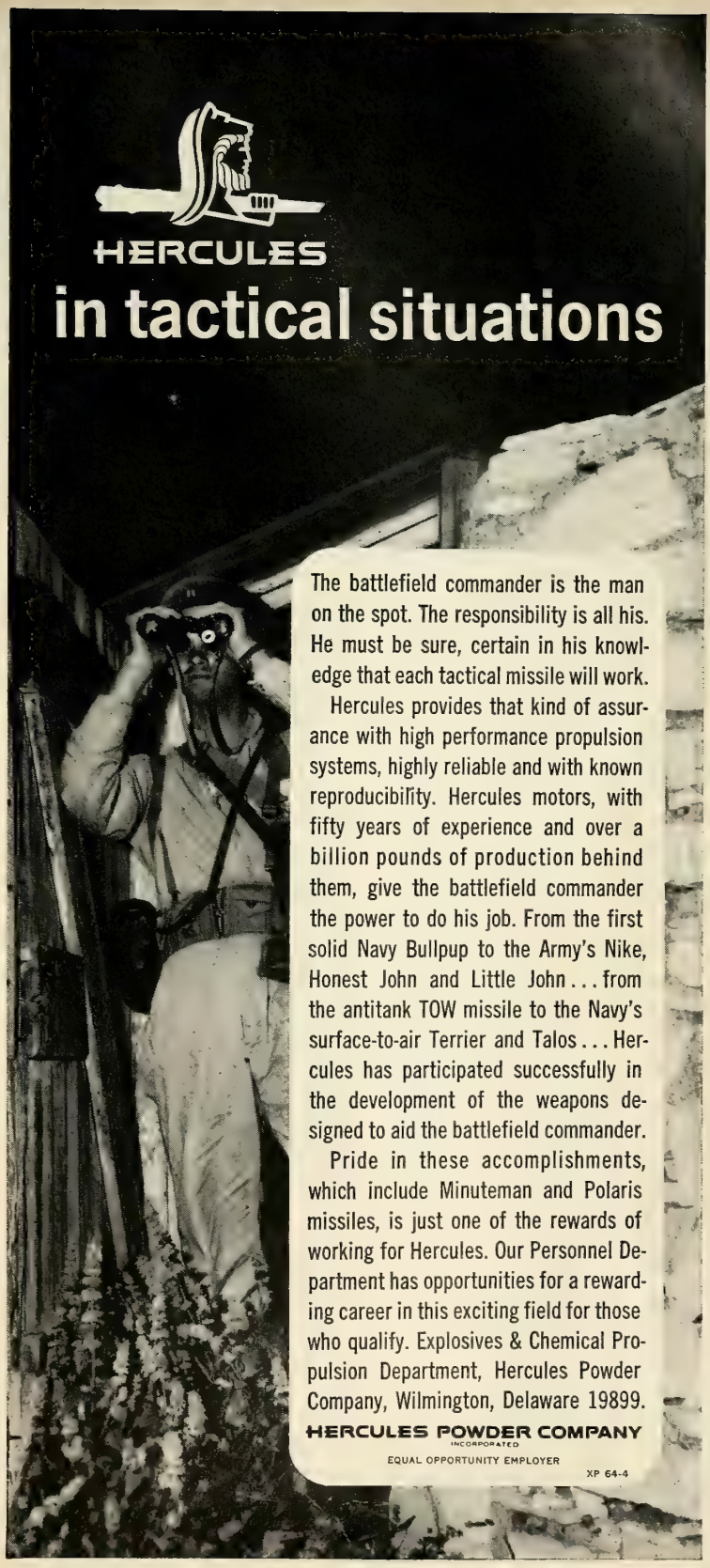
NASA Unit Moving to Cape

The majority of NASA's Launch Support Equipment Engineering Div. will move from Marshall Space Flight Center to Kennedy Space Center by next summer.

Following a plan laid down two years ago, 100 of the 140 personnel in this division will move with the launch support equipment which will be installed in *Apollo* launch and checkout facilities on Merritt Island. The remaining 40 will remain at Huntsville to support testing and modification of *Saturn V* launch support equipment still under development for fabrication. The group, which has the title of Kennedy Space Center Launch Support Equipment Engineering Div., is headed by T. A. Poppel.

Correction

IN M/R'S Fourth Annual NASA Issue (Nov. 30) the headline over the Special Report on the Weather Bureau (page 152) should read "Bureau's Spending Level Will Climb Over $40 Million During 1970's" ($40 million rather than $40 billion, as printed).



Circle No. 4 on Subscriber Service Card

McNamara MOL Decision Due

DDR&E official denies reports that program will be cancelled in favor of joint DOD/NASA orbiting lab using Apollo-X

by Hal Taylor

A DECISION by Secretary of Defense Robert S. McNamara on the future of the Air Force's *Manned Orbiting Laboratory* (*MOL*) program is imminent.

A top official of the Directorate of Defense Research and Engineering told MISSILES AND ROCKETS late last week that a decision on whether to approve substantial funding for the project in Fiscal Year 1966 will be made by McNamara within a week. "We have made a good case for going ahead with *MOL* and we have no reason to be pessimistic about its future," he declared.

His statement followed published reports that high-level NASA and DOD officials had already agreed on a joint orbiting laboratory program which would utilize the *Apollo Extension Systems (Apollo-X)* spacecraft (M/R, Oct. 26, p. 14). This system, the report said, would replace the *MOL*, which McNamara had already decided to cancel.

The DDR&E official denied the reports emphatically. He said that the *MOL* discussions were a completely in-house DOD effort ordered by the Secretary. "In order to move ahead with the *MOL* program, we will need substantial funding in the next fiscal year. We have been hard at work attempting to justify it and we expect a decision within a week," he continued.

He said that if a decision is made to scrap the program, DDR&E and the Air Force will have to look around for alternatives. He said one of the possible substitutes would be *Apollo-X*, but that this would mean at least a two-year delay in ascertaining the need for a manned military space capability.

● **Double denial**—A NASA spokesman joined in denying the reports that the two agencies had reached agreement to permit the Air Force to fly the last six *Gemini* missions and to fly all NASA unmanned payloads on the *Titan III* booster.

It was learned that the chief proponent for scrapping *MOL* is Dr. Donald Hornig, President Johnson's chief scientific advisor, who is backed by other members of the Presidential Scientific Advisory Committee.

Hornig believes that *MOL* and *Apollo-X* are duplicative efforts. MOL should be dropped, he says, because it does not have sufficient size or capability to represent a real step forward in space exploration. The committee and Hornig also believe that since the Soviet Union has already orbited three cosmonauts, the two-man *MOL* capsule would represent a loss in U.S. prestige.

The DDR&E official declared that their studies indicate that *MOL* will enable the Air Force to conduct many important experiments in space. He added that while *Apollo-X* could be used for some of them, it could not serve as a test bed for all.

● **Secretary on record**—If McNamara does decide to kill the program, it will be a complete departure from his previous position. In announcing his decision to cancel the *Dyna-Soar* project and replace it with *MOL* in December, 1963, he said that "despite the fact that they are not clear, we will undertake a carefully controlled and carefully scheduled program of developing the techniques which would be required were we to ever suddenly be confronted with a military mission in space and it is for that reason we proposed and Congress approved the *Titan III*."

"It is for that reason we are proposing the *Manned Orbiting Laboratory;* not for a precise, clearly defined, well-recognized military mission, but because we feel that we must develop certain of the technology that would be the foundation for manned military operations in space. . . ." ■

Italy To Launch San Marco Satellite

ITALY this week will become the third nation to launch a satellite into space.

The launch of the *San Marco* satellite is scheduled from Wallops Island, Va., no earlier than December 11. A NASA-trained Italian launch crew will direct the countdown of the four-stage U.S. *Scout* booster.

This will be the first time in the NASA international cooperative program that a satellite launch operation has been conducted by a team of foreign nationals. United States launch crews have placed in orbit two United Kingdom satellites and one Canadian satellite.

The 254-lb. *San Marco* satellite will be launched in an easterly direction from Wallops Island. Inclination to the equator will be 37.7 degrees. Its orbit is expected to have a perigee of approximately 135 statute miles. Apogee of the satellite is expected to be about 420 statute mi.

Objectives of the flight are to serve as a training exercise for the Italian launch crew in preparation for a sea platform operation; to qualify the *San Marco* spacecraft for a later launch into an equatorial orbit from a sea platform in the Indian Ocean near the Equator; and to provide measurements of air density and to investigate ionospheric characteristics related to interference with long-range radio transmissions.

Instrumentation in the 26-in. spherical spacecraft was tested in two suborbital flights from Wallops Island last year—April 20 and Aug. 2.

The project was conceived by Professor Luigi Broglio, chairman of the Italian Commission for Space Research and general director of the *San Marco* project. The payload was developed by Professor Broglio and his group at the Aerospace Research Center in Rome.

DOD May Toughen Patent Policies

TRW, Lockheed charged with failing to disclose inventions made under R&D contracts; ASPR's may be made more stringent

FURTHER CHANGES in Dept. of Defense patent policies may be forthcoming as a result of a number of General Accounting Office probes into contractor practices.

GAO is now preparing several more reports on specific contractors that will deal with aspects of interpretation of the patent disclosure provision on Government contracts. Last week it published its report on Lockheed Missiles & Space Co., following the same lines as that on divisions of Thompson Ramo Wooldridge. Both companies were charged with failure to disclose a number of inventions made under DOD R&D contracts (M/R, Nov. 30, p. 29).

The Dept. of Defense has indicated that it does not consider the problem a severe one, and that the May 11, 1964, increase in the withholding provision has greatly helped the situation. This increased from $5,000 to $10,000, or from 5-10% of the contract, whichever is less, the amount withheld until all inventions are disclosed, to the government.

However, GAO's position is that failures and long delays in reporting they have uncovered are evidence that this measure is not binding enough. A DOD study group is now reviewing the situation. There are indications, however, that the Armed Services Procurement Regulations (ASPR's) may be changed to provide for a larger withholding percentage.

● **Industry pressure**—One of the points industry is questioning is the new requirement that written disclosure must be made within four months. Lockheed president D. J. Haughton pointed out in a letter to GAO that this would mean that inventions must be disclosed before they are complete, and would require much follow-on material to supplement information.

In addition, he said, it may be impossible to say during this time period whether or not a patent application will be filed, since development of complete technical information and patent searches could not be completed. There are indications that DOD will lengthen this period, however, because of widespread industry complaints.

On the subject of confirmatory licenses, which are filed with the Patent Office and show the government's right to royalty-free use of the invention, answers by both TRW and Lockheed show that there is some confusion about the filing of these documents.

Although DOD has followed the practice in some cases of preparing the confirmatory license itself, GAO said, the ASPR's indicate that the contractor has this responsibility. GAO also said that it has brought to the attention of DOD that there is no fixed period of time in which these licenses should be filed, and that the ASPR's should be amended to make such a provision.

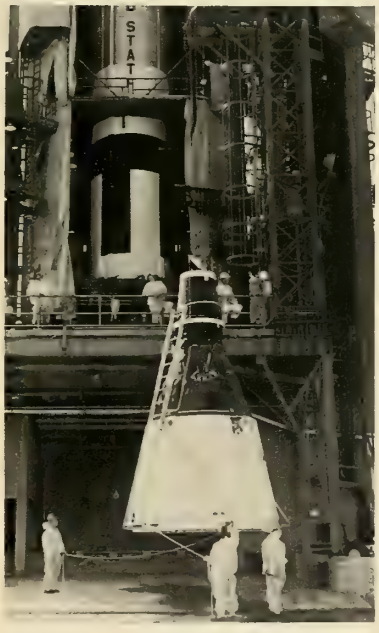
● **Lockheed & TRW**—In last week's report, GAO charged that Lockheed failed to disclose to the government 58 inventions that had been made under defense contracts up to 23 months previously. It also charged a number of non-disclosures going back as far as 46 months.

TRW Computers and Space Technology Laboratories, subject of the previous reports, allegedly did not disclose some 18 inventions that had been made up to 3½ years ago and others as far back as four years ago.

In both instances, GAO said, the patent rights of the government have been jeopardized, since it was not aware of inventions in which it had contractual rights to royalty-free use or to obtain title to the invention. "Consequently the Government may have paid royalties unnecessarily for the use of such inventions and may have lost its rights to such inventions because of intervening patents by third parties," the GAO report stated.

GAO has strongly recommended that additional financial sanctions be imposed on delinquent firms—in the form of liquidated damages for contractor failure or delay in reporting inventions. It also has proposed to DOD that the military services adopt "adequate surveillance," including review of the filing of patent applications by the government. This would avoid the jeopardy of publication or lack of diligence, it said.

GAO Associate Director Harold H. Rubin said that the probe, which began last year, was started at the office's own initiative and was not requested by any Congressional committee. ■



Gemini Mated to Titan II

GEMINI II spacecraft, weighing approximately 6,900 lbs., is hoisted in the gantry to be mated to the Titan II launch vehicle at Cape Kennedy. GT-2 flight, set for no earlier than Dec. 8, is intended to flight-qualify the entire spacecraft as an integrated system for manned space flight. The suborbital unmanned mission should last about 20 min., the capsule should achieve an altitude of about 106 mi., and should travel approximately 2,150 mi. downrange from Cape Kennedy.

Mid-Course Correction Decides Mariner Fate

Russian Mars probe launched three days after U.S. spacecraft encounters power supply problems early

THE U.S. IS APPARENTLY leading in the race to explore Mars as the *Mariner IV* spacecraft thus far has performed perfectly while its Russian competitor, *Zond II*, has encountered problems with its power supply.

On Dec. 2, 1964, the U.S. spacecraft was 771,263 statute miles from Earth and 125.4 million miles from Mars and traveling at a speed of 7,123 miles per hour.

The Russian spacecraft was launched Nov. 30, three days after *Mariner IV* successfully lifted off the pad at Cape Kennedy. This put the NASA spacecraft ahead of the Russians, but the probable heavier propulsion capacity of the Russian booster could enable it to catch up later.

● **Russian power problem**—Shortly after launch the Russians announced that the spacecraft's power supply was 50% less than expected. U.S. officials said that while the Russians had probably overdesigned to cover such a possibility, the loss of power was apparently serious or they would not have made a public announcement.

There was also immediate speculation that the Russians would launch another spacecraft before the current launch window ends early this month. During previous planetary launch opportunities, they have always made several launch attempts.

U.S. officials reported that two objects in orbit—the Russian launch vehicle stages—decayed Dec. 1. There was no report on the spacecraft trajectory or velocity by U.S. tracking stations.

● **Guidance correction critical**—A crucial step in the *Mariner* flight—a mid-course guidance correction—was scheduled late last week by scientists at the Jet Propulsion Laboratory. If successful, they said it would put the spacecraft within 8,000 miles of the planet about July 14-15, 1965. The maneuver was expected to be made on either Dec. 3 or 4 at about 2 a.m.

During the brief encounter, *Mariner IV* is scheduled to record 22 photographs of the Martian surface on tape and play them back for re-recording at NASA's Deep Space Instrumentation Facilities at Goldstone, Calif.; Johannesburg, S. Africa; and Woomera, Australia.

The *Mariner IV* Mars fly-by spacecraft was launched on a successful trajectory from Cape Kennedy at 9:22 a.m. EST Nov. 28.

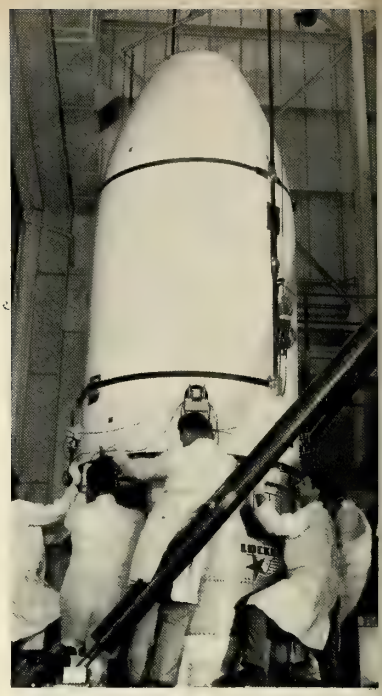
● **Why it slipped**—The launch, originally scheduled for the first week in November, was delayed when *Mariner III* failed to extend its solar panels in flight and battery power was exhausted through lack of recharge capability.

Project officials agreed that a structural failure had occurred in the fiberglas honeycomb shroud that protected the spacecraft during passage through the atmosphere.

Consensus of engineers pointed toward replacement of the honeycomb structure with a more rigid material, and Lockheed Missiles and Space Co. fabricated a magnesium alloy shroud to replace the honeycomb. Two of the structures, both coated inside and out with Fiberglas material, were fabricated, with one going to the Cape and one remaining in California for testing.

The *Mariner IV* launch was then reset for Nov. 27, but fluctuating signal strength from the spacecraft radio forced a 24-hour delay.

● **Launch vehicle performance**—Countdown and launch of the *Atlas D* first-stage booster was described as "perfect" by Bob Gray, chief of Goddard Space Flight Center's launch operations team at the Cape. It marked the third time in a row an *Atlas* space booster had been launched exactly on schedule from Complex 12 and was the 24th consecutive success for the *Atlas* as a booster.



MAGNESIUM alloy shroud used to protect Mariner IV during ascent undergoes tests at Sunnyvale, Calif., plant of Lockheed Missiles & Space Co. Mariner III failure has been blamed on failure of glass fiber shroud, which apparently did not separate from the spacecraft properly, causing the probe to lose power when its solar cells could not be exposed to the Sun. Mariner IV is scheduled to pass Mars July 14-15, 1965.

A check of *Atlas* performance data revealed booster velocity was one-half foot short of perfection, but was well within the seven feet per second allowable. Pitch was between three and four feet per second low compared to an allowable 64 fps, and yaw was 4.5 fps to the right compared to an allowable 64 fps.

Agena D performance also was excellent, and the initial trajectory without correction would provide a miss distance of 200,000 miles, well within the 750,000-mile correction capability of the on-board mid-course correction motor.

If the correction is successfully accomplished, *Mariner IV* will have traveled 325 million miles at encounter and will be some 134 million miles from Earth when picture playback starts after the sweeping photo pass at Mars.

The tape bearing the pictures is scheduled to be played twice, but can be repeated many times on command from Earth if additional transmissions are indicated or required. ■

Third in series . . .

Apollo Launch Escape Test Due

Little Joe II-boosted shot, scheduled no sooner than Dec. 8, to simulate catastrophic launch vehicle failure at White Sands

THE THIRD in a series of possibly eight tests of the *Apollo* launch vehicle escape system will be carried out this week using a *Little Joe II* booster and boilerplate *Apollo* command and service modules.

Launch, scheduled Dec. 8 at the earliest, will be made from White Sands Missile Range, N.M. It will simulate a catastrophic launch vehicle failure at maximum aerodynamic pressures. From the 4,000-ft.-altitude White Sands launch site, this pressure region is attained 31,000 ft. above the range.

NASA has scheduled another boilerplate escape test for the second quarter of 1965, after which three or four tests will be made using the actual *Apollo* spacecraft to see whether subsystems function properly during abort.

This week's test differs from the two previous ones in which the launch escape system was used to demonstrate pad abort and high-dynamic-pressure abort. In the latter, which was conducted last May 13, one of the three parachutes failed to deploy, but the spacecraft was landed safely.

● **Objectives**—The following equipment will be tested for the first time in the upcoming test:

—Canards, located near the top of the tower jettison motor to turn the Command Module heat shield forward to damp descent oscillations during abort.

—The boost protective cover, a shell that fits on the sloping section of the Command Module, will be jettisoned with the launch escape tower. This cover protects the Lunar Excursion Module docking mechanism from excess heating during first-stage boost and protects Command Module windows from soot and erosion from the launch escape motor. It also is designed to protect the thermal control paint on the ablative materials.

—Two spacecraft drogue parachutes, which will be used instead of the one formerly used.

● **Flight schedule**—After launch from White Sands, at which time the vehicle will be oriented in a northerly direction at an angle of about 84 degrees to the horizontal, the spacecraft will follow a normal boost phase until T plus 35.5 seconds. At this time, the spacecraft should be at 26,000 feet, and a pitch-up maneuver will be initiated by radio command. This will place the vehicle into the angle approximating the emergency escape attitude for the spacecraft.

Abort will take place at 37 seconds after liftoff. In this sequence, the Command Module, a 13.2-ft.-long, 154-in.-wide boilerplate weighing 9,600 lbs., will be separated from the boilerplate Service Module. This structure is conically shaped, 11 ft. 3 in. high, 154 in. wide and weighs 10,000 lbs.

The boost protective cover, which extends over the entire conical surface of the Command Module, consists of a hard upper third portion of glass honeycomb over Teflon-impregnated glass cloth. The lower two-thirds or soft portion is constructed of ablative cork over Teflon-impregnated glass cloth. The glass cloth assures a smooth surface for easy removal when the tower is jettisoned.



LAUNCH escape system for Apollo boilerplate command and service modules being mated to Little Joe II launch vehicle.

The vehicle will carry a telemetry system, motion picture cameras and a tape recorder. Electrical power will be supplied by one 1,500-watt-hour and four 140-watt-hour silver-zinc batteries.

Launch escape motor and pitch-control motor are both supplied by Lockheed Propulsion Co. The solid-fueled launch escape motor weighs 4,800 lbs., is 26 in. in diameter and 183 in. long. Thrust of 155,000 lbs. for six seconds is provided by burning about 3,200 lbs. of solid fuel. The pitch control motor, also solid fueled, is 9 in. in diameter and 22 in. long.

● **Post-abort**—Eleven seconds after abort initiation, the canard subsystem, which consists of two pyrotechnic-actuated stabilizing "wings" about 18 in. wide and 24 in. long, are actuated. These turn the launch escape vehicle around so that the blunt or heat-shield end is forward, minimizing Command Module descent oscillations.

Altitude of the launch-escape vehicle at this point will be about 46,000 ft. above the range and it will be 48.5 seconds from launch.

At 116 seconds, the tower structure of the launch escape subsystem, which is about 120 in. long, with a base of 40 x 50 in., is jettisoned with the boost protective cover and the forward heat shield. Tower jettison motor, developed by Thiokol, has a gross weight of 550 lbs. and develops 33,000 lbs. thrust for one second. Four single-mode explosive bolts, each equipped with a dual ignition feature to increase reliability, constitute the tower release mechanism.

Drogue parachutes will be deployed about two seconds later, when the vehicle is about 19,000 ft. above the range. The vehicle is expected to impact about 32,000 ft. uprange.

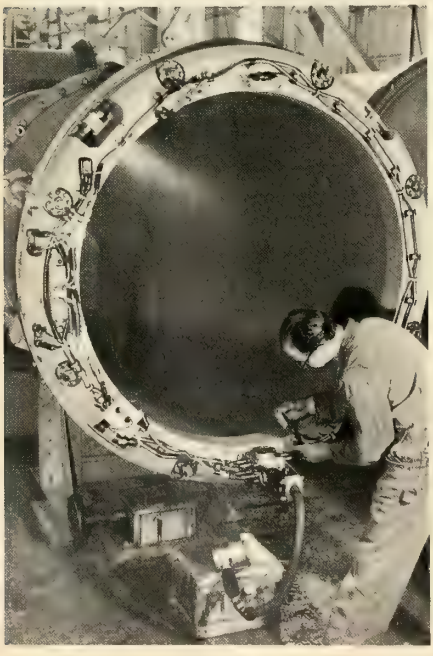
Other contractors involved in the test are: General Dynamics, *Little Joe II* booster; Aerojet-General Corp., Algol motors; Thiokol Chemical Corp., Recruit motors for the *Little Joe;* and Northrop Corp., landing system. ■

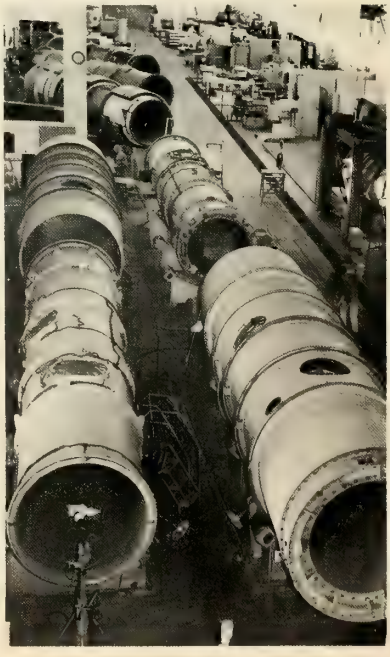




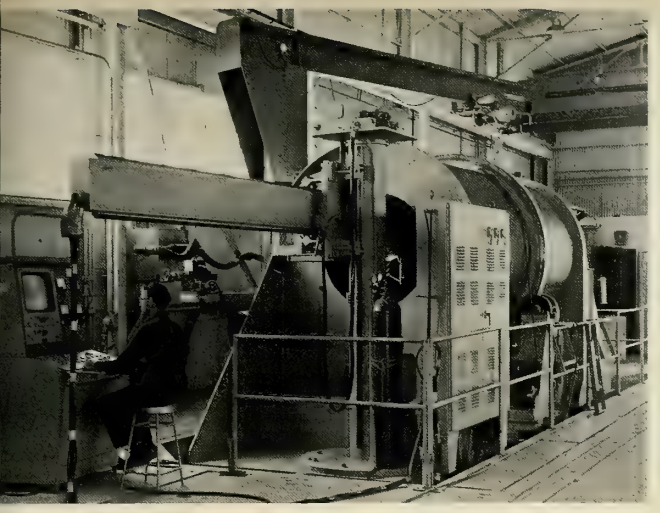
Polaris A-3 Launch Tube Production

TOP LEFT: Materials stockpile at Westinghouse Electric Corp.'s Sunnyvale, Calif., facility constantly feeds the $200-million Polaris A-3 launch tube program. Five sections per launcher, with two flanges on each section and 16 launchers per submarine, require a continuing supply of steel in the receiving yard. TOP CENTER, LEFT & RIGHT: First step in the launcher assembly program is section welding. The high-strength, lightweight jacket section is welded on remote-controlled, television-monitored welding fixtures. TOP RIGHT: Access doors are hinged so that they are completely out of the way during servicing of the missile. Each is both mechanically and electrically locked. The foam bags visible here are part of the shock mitigation system designed to give the launch tubes the same ruggedness as the parent submarine, as well as to provide for the launch environment. The bagged-foam packages are evacuated before the tube is slipped into the outer shell. BOTTOM FAR LEFT: Lower end of launcher shows the support ring with its clamps, indicator switches and detectors to monitor and control Polaris during long sea stowage. BOTTOM CENTER, P. 14: Final assembly area at Westinghouse-Sunnyvale. The launcher tube (left fore-







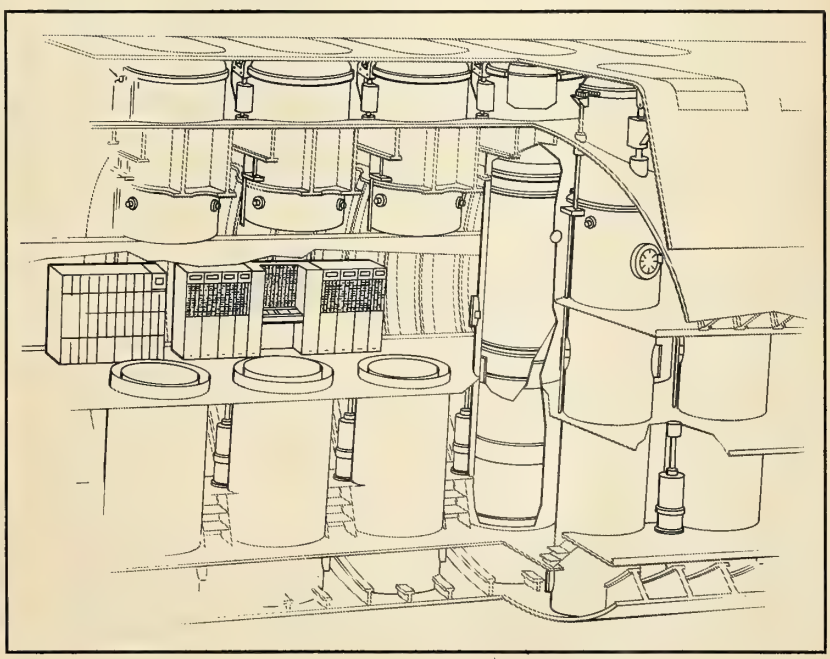


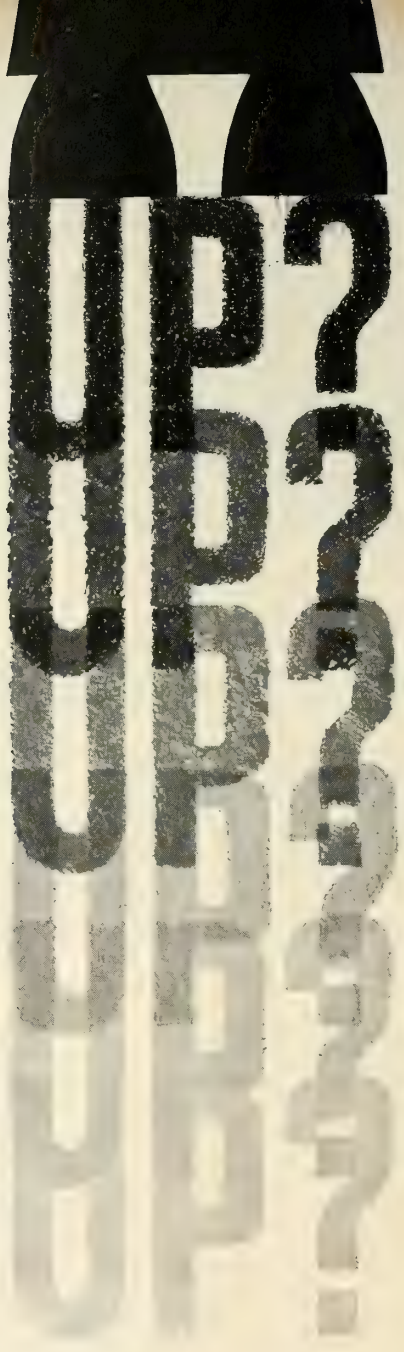


Vestinghouse: A Step-by-Step Report

ground) is padded with polyurethane foam (background upper left) and inserted into the jacket, creating the launcher module (right foreground). The module is shipped to the submarine fabricators for installation. BOTTOM RIGHT, P. 14: The rocket motor portion of the steam eject system is covered with handling hooks and has a heavy thrust neutralizer bolted to the base for handling and shipping. The rocket motor superheats water which in turn is admitted to the base of the launch tube with the rocket exhaust gases, forcing the Polaris A-3 out of the submarine. BOTTOM LEFT, P. 15: Precision barrel assembly area is shown with a launcher tube at left being readied for shipment. The pipe rack assembly is part of the shipping procedure. The tubes have a number of mechanical and electrical subsystems attached here for future mating with the Mark 21 Launching System. Westinghouse also builds the control system at this plant. The Integrated Monitoring Panel (IMP) is also fabricated here. BOTTOM RIGHT, P. 15: Drawing of tube section aboard Polaris submarine shows the launching system in place with the Westinghouse control console. There has never been a failure in the operation of these launching systems in the Polaris program.







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Technical Countdown

ELECTRONICS

Hydrogen Atom Clocks To Check Relativity

Two H-10 atomic hydrogen maser clocks will be evaluated by scientists at NASA's Goddard Space Flight Center for possible use in high-precision satellite tracking as well as experiments testing Einstein's prediction of the effect of gravity on time. The clocks, developed by the Quantum Electronic Devices activity of Varian Associates, use the natural oscillation resulting from the interaction of the proton and the electron in the hydrogen atom. These atoms, under proper conditions, will emit energy at a precisely known frequency of 1,420,405,751.732 cps. The natural stability is such that the Varian H-10 maser will produce this exact frequency with month-long stability better than 5 parts in 10^{13} RMS.

EOS To Build Airborne Laser Beacon

A complete laser beacon system for use aboard high-performance, high-altitude aircraft will be designed and built by Electro-Optical Systems, Inc., under a contract from the National Aeronautics and Space Administration. The Xerox subsidiary will deliver the system to NASA's Flight Research Center at Edwards, Calif., early next year. In operation, the system will be mounted beneath the aircraft and used to send wide, coherent spherical wave fronts to ground tracking stations for in-flight azimuth and elevation angle data. Laser operation will be at 100 pulses/sec. through a Xenon flash unit. The laser rod will be yttrium aluminum garnet doped with neodymium. The wave fronts will be observed by optical trackers designed to black out all lightwaves other than the 1.06-micron infrared laser wavelength.

Surveyor Landing Radar in Advanced Tests

The radar and Doppler velocity sensor system destined to assist the *Surveyor* spacecraft in its soft landing on the Moon is now in the advanced test phases at Ryan Electronics. Flight tests of the system using helicopters at Holloman AFB and at the Hughes Aircraft Co. airport have been successfully completed. These flights ran from 6,000 to 20 ft. above the ground. In the actual *Surveyor* mission, the landing radar and Doppler velocity sensor will operate from 50,000 ft. altitude to the lunar surface. Controlled drops of the spacecraft from balloons have been started, simulating the final lunar descent. The Ryan system controls the craft's vernier rocket system in the final landing approach.

JOVIAL Compiler To Be Built for Navy

Planning Research Corp. will develop a JOVIAL compiler for the Navy's militarized computer under a $162,000 contract with BuShips. The compiler will process the JOVIAL language on the Univac CP-667 computer. The generated programs will be run on a computer system with the CP-667 as its control processor. The compiler will enable the Navy to write command and control programs in JOVIAL.

Highly Stable Transmitter for Saturn

Leach Corp. will build an undisclosed number of 2-watt solid-state telemetry transmitters capable of maintaining a state-of-the-art frequency stability of 0.005% within an assigned center frequency under all specified environments. The contract was awarded by the Brown Engineering Co., subcontractor to NASA's Marshall Space Flight Center for the electronic system integration and checkout on the *Saturn* program. The solid-state units will be a standard IRIG transmitter operating on a standard telemetry bandwidth of 215 to 265 mc. The frequency stability will be achieved through design extension and improvement of an existing 2-watt telemetry transmitter with a frequency stability of 0.01%.

MATERIALS

New High-Temperature Fiber Developed by J-M

A hydrous magnesium fiber called TX with an ultimate temperature resistance of 5,070° F is being marketed by Johns-Manville's Aerospace Products Dept. The reinforcing fiber contains about 28% of chemically combined water. During hyperthermal exposure, some of this water is released and the fiber functions partially as a transpiration cooling mechanism. TX laminated plastics have flexural strengths in the range of 15,000 to 18,000 psi and tensile strengths of 9,000 to 11,000 psi. The modulus of elasticity is about 2.4 x 10.6 lbs./in^2. Prototype parts have been subjected to rocket firing tests and J-M spokesmen say the results showed TX components to be superior to all others in the evaluations—which included graphite, silica and asbestos reinforcements. The configuration tested was a TX-reinforced ablative thrust chamber.

ASTRONAUTICS

Vacuum Cleaner for MOL Under Development

A combination vacuum cleaner and fire extinguisher for the *Manned Orbiting Laboratory* is being developed by Lockheed Missiles and Space Co. Dubbed VacGuard, the device operates on the pressure difference between the cabin and outer space. It is designed to control cabin fires, remove unwanted solids, liquids and gases and to control sudden leaks in the space cabin wall. The device consists of an adapter, a flexible hose and a selector valve.

SPACE MEDICINE

Brainwave Communication Demonstrated

An Air Force scientist at Cambridge Research Laboratories has successfully demonstrated that communications can be made through brain waves. According to Dr. Edmond M. Dewan, trained subjects can alter the pattern of their brains' alpha rhythm, the low frequency wave related to visual perception. The alpha rhythm can be turned on and off, allowing the use of a binary digit system or Morse code for communication.

Spacesuits Will Get Rigorous Testing

Apollo and *Gemini* spacesuit prototypes complete with life support systems are to undergo extreme environmental testing next year with a dummy constructed of copper and glass fiber inside. The dummy, which will thermally simulate man, will have 50 temperature sensors to measure effectiveness of the suit protection to different portions of the body. It also will be jointed to study how movements, such as kneeling on the hot or cold surface of the Moon, will affect this protection. Visor fogging also will be simulated. The study will be done in Ling-Temco-Vought's space environment simulator, which will use liquid nitrogen for extreme cold, and mercury xenon lights to simulate the Sun.

Pentagon's New Stress on Tactical C&C Systems Highlights ISS Meeting

by Michael Getler

HOT SPRINGS, VA.—Steadily increasing Dept. of Defense interest in application of new command and control systems at the tactical level, and in the study and development of the processes of "crisis management" within the top echelons of the government, are expected to have an important impact on future U.S. development of information systems.

Influence of increased activity in both these areas was apparent at the Second Congress on the Information System Sciences, held here Nov. 22-25, and was in sharp contrast to the first meeting of the congress two years earlier, when heavy emphasis was placed on developmental problems faced by the large and primarily strategic command and control systems (M/R, Dec. 3, 1962, p. 16). The conference was sponsored by the Air Force's Electronic Systems Div. and The Mitre Corp.

There are several reasons for the increase in activity in the tactical areas. First, the growth of weaponry has expanded greatly in order to afford a defense policy of flexible response, and field commanders must have a very high degree of control over some of these weapons, particularly those used for air defense and nuclear offense. Second, there is a growing tendency for the U.S. to rely on combat echelons based in this country and able to move quickly over long distances, taking with them lightweight C&C equipments. A third, and very important, reason is that development of new microelectronic circuitry applicable to design of very small control devices or field computers will allow use of automated systems in areas where this has previously been impossible.

Dr. Eugene G. Fubini, Deputy Director of Defense Research and Engineering, who keynoted the meeting here, said at a press conference that his office was attempting to "encourage" firms that have concentrated on strategic systems to get into the tactical areas in order to meet this "redistribution" of effort between the two. Fubini listed reconnaissance, control of air space, and logistics as among those areas where new systems developments are possible.

Herbert D. Bennington, technical director of the Joint Chiefs of Staff command and control requirements group, told M/R that tactical systems will represent the "richest application of C&C activity in the immediate future." Bennington also said that within the JCS, specifically, there was increasing interest in "making sure the operational characteristics of the service-developed systems are compatible."

● **New approaches**—Spurred on by the mounting DOD concern with lower echelon information systems, industry experts in this area interviewed by M/R are focusing on several possible new applications. For example:

—The increasing accuracy of current surface-to-air antiaircraft missile systems (and the expected gains with new systems) could pose a problem for missile crews unable to get a rapid verification of friend or foe from an aircraft, particularly in front-line areas where attacks may be at very high speeds and low altitudes. The problem will become acute, some observers believe, when in the near future the U.S. may have in the field widely dispersed antiaircraft missile weapons which can be operated by one man. An example of such a system is the shoulder-fired *Redeye* missile now under development. The World War II adage of "shoot 'em down and sort 'em on the ground" may have to be modified, as one expert puts it, "when you are pretty sure you are going to hit what you shoot at."

Planners believe that considerable improvements can be made in airborne IFF systems and that development of microcircuitry should allow very small interrogation systems to be developed for use with some of these single-operator missile systems to provide surer weapon control.

—In the tactical air strike situation, some observers believe, that new information processing schemes can yield simulation techniques for gathering vulnerability figures associated with planned low-level high-speed terrain-following strikes. By "Digitizing" the known terrain and by cranking in various defense system acquisition times (and the location of the defensive sites if known) it is thought that a simulated aircraft could be run through a specific mission, showing not only the probability of success but perhaps the best way to use the terrain to accomplish the mission.

This same technique, if mastered by an enemy, would impose its own problem on air defense, which could become ineffective in that it too becomes masked by the terrain. Some observers believe this possibility will demand development for new airborne air-defense and weapons control systems beyond those which now exist.

—In the intelligence and reconnaissance areas, some planners feel there will be a need for a critical review of all existing systems, including those generally associated with only a single-user service, with an eye toward making better, and possibly more widespread, use of data.

For example, electronic signature detection systems which are used primarily to provide a key to an enemy's activities and whereabouts might also use data collected from signals emanating from friendly forces which might be useful in providing a more accurate picture of the dispersion of these forces to a field commander.

Several new microelectronic and electro-optical on-board data processing efforts are now under way within industry, some of them funded by the Air Force in a move to provide greater real-time inputs to the various I&R systems

(M/R, June 1, p. 30; Nov. 23, p. 22).

—Another area which is demanding more attention is that of control over tactical nuclear weapons, ranging from artillery-delivered warheads to nuclear-tipped missiles and bombs delivered by aircraft. While systems are in existence covering these weapons (M/R, March 30, p. 84), some observers believe these will have to be refined to the point where virtually new C&C systems are necessary.

Inputs such as weather and nuclear fallout pattern predictions, and the ability to provide informative briefings to widely dispersed tactical air force pilots who could, for example, be charged with delivering nuclear weapons upon targets of opportunity, will need to be improved. C&C equipment that is very easily transported, say in a single aircraft, will be required. Some experts view this field as quite critical, pointing out that improved control will have an effect on how a tactical war is fought and, in turn, how it might escalate.

One of the primary roles intended for the Army's CCIS-70 automated data processing field systems now under development is in this area of nuclear target analysis and fire planning. Described at the conference, the fire problems were judged "sufficiently complex that the aid of a computer appears essential."

Within the Navy, there is now in progress a major expansion of new data processing systems to be used in connection with anti-submarine warfare and target signal analysis (M/R, Sept. 21, p. 46).

● **Capturing data**—At the conference, the most public support for tactical information systems came from Marlin G. Kroeger of the Autonetics Div. of North American Aviation, Inc.

Kroeger sees tactical level automation as more in keeping with the rule of "capturing data at its source," something he feels that designers of strategic systems have violated. Kroger points out that much of the data captured at tactical echelons would be put immediately into a format that will make some or all of the data useable throughout military information systems. He cautions, however, that strategic systems already in existence could impose certain inefficienies at the lower levels in terms of format variations and development of dual-reporting channels. He called for major attention to be given within the DOD to the job of imposing interconnection standards between isolated service-developed systems.

A discussion of some of the factors in so-called "crisis management," which now takes up an increasingly larger portion of DDR&E's time (M/R, March 30, p. 80), by Daniel Ellsberg, a special assistant to the Secretary of Defense for International Security Affairs, revealed two major items of interest for information systems designers:

● **Lonely decision**—For one, the role of the President of the United States in the decision-making process which accompanies major international crises is a large and peculiar one, and, as Ellsberg put it: "The importance of command and control now is that the President *personally* must be kept very much in mind. Some earlier planning may have been unrealistic in terms of the President's role," he said.

While Ellsberg did not say how this could be done, what he *did* say makes it appear that information specialists have a problem on their hands.

For example, Ellsberg, who insiders say has made the most penetrating study ever performed of the Cuban missile crisis, pointed out "the decision-making process is secret to a very unusual degree," and that the impression of anyone, outside of an extremely small group of persons, "is almost certain to be wrong."

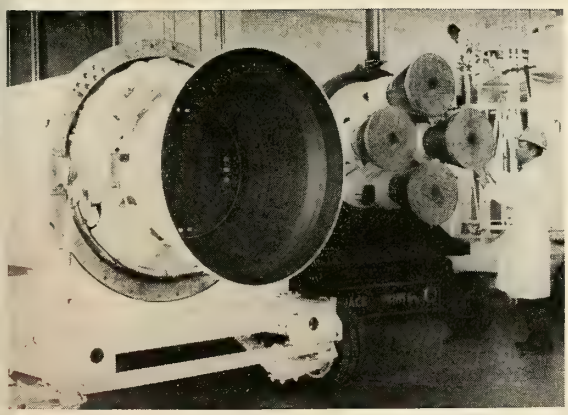
Ellsberg said that the President's role is so closely guarded that he, in effect, comes to his job "as an amateur" regarding some of these matters. Once in office, the President must choose his closest advisors with an awareness of the potential cost of "leaks" regarding his role in any number of crises. One observer points out that this consciousness at high levels that "not everybody is on the team, even in the Cabinet," can give rise to leaks or political embarrassments.

The fact that a crisis comes to the surface at all has significant political implications for the President, for as Ellsberg pointed out, it generally implies that "something appears to have failed," or someone has failed to foresee, or had foreseen and then failed to prepare or handle it.

"The President," Ellsberg noted, "has an extraordinary range of information available to him, but despite this, quite shocking surprises do occur." He said not only Cuba contained its element of surprise—the Suez crisis, for example, "had also surprised Eisenhower and Dulles." Ellsberg added that there are numbers of crises which "are successfully hidden."

With these things in mind, Ellsberg pointed out that an administration has almost nothing to gain by an outsider getting a piercing look at the total decision-making process during a crisis. For example, though the outcome of the crisis may appear good, the management of the crisis may have been rather poor.

● **Military bypassed**—The other area of interest to information scientists is in the military input to these crisis management situations. Ellsberg noted that during the Cuban missile crisis, only General Maxwell Taylor was represented among the dozen or so members of the so-called Ex-Comm offshoot of the National Security Council. Ellsberg said there is a need to improve the military output, so that it gives a more reliable input in this type of situation, but also indicated that one of the reasons why the military may be "frozen out" of this process is because Pentagon planning staffs may not be suited to the pace of decision-making in this crisis-management area. ■



Minuteman II Second Stage Shown

A LARGER and more powerful second-stage solid-propellant rocket motor under development for the Air Force Minuteman II ICBM features a large single nozzle (left) rather than the four-nozzle configuration of the operational Minuteman I. The advanced motor will give Minuteman II longer range or a greater payload capability than its predecessor has. The now operational motor moves its nozzles to direct the missile's flight during second-stage operation. The advanced version has a hot-gas pressurizing system that injects vaporizing liquid into the nozzle to achieve thrust-vector or direction controls. A second hot-gas system provides roll control. The new rocket control system was developed by the Space-General Corp., El Monte, Calif., under contract to the Aerojet-General Corp., second-stage propulsion contractor.

New Type of Spacesuit May Be Needed for MOL Astronauts

by Heather M. David

POSSIBILITY that the Air Force's *Manned Orbiting Laboratory* will require development of a new kind of spacesuit has been raised by the chief medical officer on the project.

Col. Andres Karstens, Aerospace Medical Div. officer assigned to the *MOL* group under Brig. Gen. Joseph S. Bleymaier, commander of the Air Force's Space Systems Command, said that it may be possible that *MOL* astronauts can wear a lightweight, continuous-wear pressure suit that would afford adequate protection during an emergency until a regular pressure suit could be donned.

The alternative to this, unless analysis shows that failure potential is so low that no such precautions need be taken, would be for one astronaut to remain suited most of the time, with helmet on and hooked up to his suit umbilical for ventilation.

The Air Force is working with NASA to develop spacesuit techniques. However, while NASA is fairly well committed to design on the *Apollo* and *Gemini* suits, the Air Force could still embark in a new direction. NASA Astronaut Scott Carpenter recently voiced the wearer's point of view when he said that pressure suits are obsolete, undesirable and quite uncomfortable.

• **Conditioning devices**—Aerospace Medical Division is now soliciting responses from qualified contractors for development of prototype spaceflight devices to diminish or prevent the deconditioning effects of weightlessness and associated environmental factors. Although *MOL* is not specifically named in the procurement, it is obvious that any such development would, if possible, be integrated into it.

AMD, through its Brooks AFB, Tex., contracting office, will let one or more two-month study contracts, then a six-month development and testing contract under which three devices will be delivered to the Air Force.

In discussing the problem as applied to *MOL*, Karstens said that the main problems are with the muscular system and circulatory system. Extensive investigations conducted with bedrest studies have given confidence in the effectiveness of some exercise techniques, combined with one of several means for "intermittently displacing some of the circulating blood to the limbs and skin"—presumably by pressure cuffs or breathing techniques.

However, it is the length of the mission which will dictate whether extensive countermeasures must be taken. Karstens said use of "some sort of rotational device," apparently meaning a centrifuge, would be "undesirable" as a solution to the physiological problems.

• **Orientation**—The *MOL* vehicle probably will be oriented so that its "up" end is toward the *Gemini-B*. Astronauts should have no problem adjusting to this, Karstens said, even though the long axis is parallel to Earth. This arrangement will greatly facilitate mock-up evaluations, testing maintenance and final checkout, he said.

• **Atmosphere**—Pure oxygen at 5 psi, as in the case of NASA's *Gemini* and *Apollo* space programs, seems now to be preferred to 7-psi nitrogen/oxygen. The bends problem, which is proving to be greater than expected as the men perform mission-type tasks, is obviously solved by using oxygen during the early phases of the *MOL* mission when extravehicular operations might take place.

The critical phases of boost and reentry are the ones in which there are physiological advantages in using a mixed-gas system because of absorption effects from the lungs and middle ear. However, Karstens indicated, these are the very phases that must be committed to pure oxygen in case pressure-suit operation is necessary.

Further tests on fire hazards and other considerations are being studied in advance of the final decision. Karstens also said that he hoped that the controls system for the two-gas system could be simplified to the extent that the decision could be based upon the merits of the gases themselves, rather than having to consider the amount of time that would be necessary to monitor the system.

• **Water supply**—Since it seems almost certain that fuel cells will be used as the power supply for *MOL*, Karstens said, water will be available from this source as well as from cabin condensation.

Non-regeneral carbon-dioxide control systems at present appear to be most reliable, Karstens said. He stressed, however, the fact that regenerable sorbers should be developed for follow-on use. ■

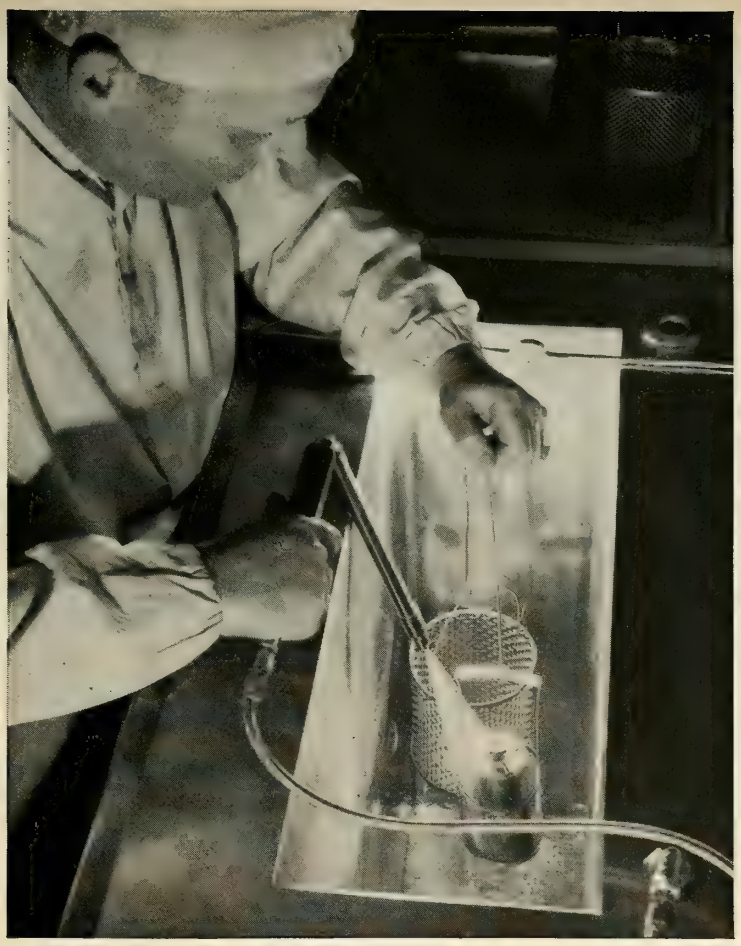
Chimps Exceed Expectations in Vacuum

AIR FORCE RESEARCHERS doing decompression survival tests with chimpanzees at Holloman AFB, N.M., are revising their ideas about how long primates can live in vacuum.

Maj. Herbert H. Reynolds, scientist for the Air Force's Aeromedical Research Laboratory at Holloman, said that chimps have been exposed to space-equivalent vacuum for up to 150 seconds, after which they were totally impaired for 37 and a half minutes. During this time, their bodies expanded, and after a few seconds of functioning, they lapsed into suspended animation. However, their body fluids did not boil, as has previously been expected.

When spaceship pressure was restored, the animals also began to recover, eventually returning to normal with no apparent injury, Reynolds said.

The scientist further noted that he wanted to do another year of work to verify his conclusions, but said the work thus far is very encouraging. Limit of survival has previously been set at from 10 to 15 seconds.



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LOCKHEED-CALIFORNIA Company's "Ping-Pong" reconnaissance rocket.

missile systems

'Bounce-Back' Recon Rocket Under Operational Evaluation

LOCKHEED-CALIFORNIA CO. has conducted successful feasibility tests for the Army of a prototype photo-reconnaissance rocket called "Ping-Pong," which can be fired into a target area to take photos and then returned by retro-rocket.

The vehicle is presently under evaluation for operational requirement at the Army's Combat Development Command at Ft. Belvoir, Va.

The prototype rocket was launched from a mortar-type tube. A solid motor lofted the vehicle into a target area where pictures were taken automatically. A timer then activated a solid retro motor, which reversed the path of the missile. The motors, both off-the-shelf varieties, were mounted at either end of the vehicle, which was stabilized by a fin that slid from one end to the other when it reversed direction. The test was conducted at Rosamond Dry Lake 80 miles north of Lockheed-California's Burbank plant.

The $250,000 feasibility study was funded by the Army Electronics Command in May, 1963, but determination of an operational requirement is up to the Combat Development Command.

Lockheed describes "Ping-Pong" as light-weight, small, reusable and relatively inexpensive to produce. Competing concepts include the Goodyear "Boomerang," Chrysler's "Snooper Shell" and Beech's "Peeping Tom." ■



Mission control center for simulated flight

Joint GE/USAF test adds data on value of simulatio man's utility for MOL

Two US Air Force Aerospace Resear Pilot School faculty members "f ing" a carefully-programmed 15-d simulated orbital mission at Gene Electric's Valley Forge Space Tec nology Center have demonstrated ab ity beyond expectations in handli potential MOL tasks.



Space cabin simulator

Their space cabin, especially designed to MOL requirements, was based on results of G-E's previous four-man-30-day "Terranaut" test. Atmosphere again was 50/50 nitrogen-oxygen at 7 psi. The crew's mission-task profile and s tem limitations subordinated all p sonal considerations to a demandi eight-on, four-off work-sleep schedu

Realistic orbital tasks were p grammed: station keeping; equipme maintenance; rendezvous using C simulators; navigation experimer using man-controlled Orbiting Ast nomical Observatory hardware, wh men did the job with less fuel; complete re-entry program perform manually; plus other experimer



Control panel segment

pertinent to ture orbital m sions. Tas scheduled daylight had be completed that period "orbit". Comm nications w ground stati terminated they theoretically passed out range.

The test proved the value of s tem-level simulation for performar evaluation and pilot training, a that mission-goal orientation trained, motivated pilots can ov come the most demanding conditi of orbit. For more information, wri Mgr., Manned Orbital Laboratory Pr ect, Valley Forge Space Technol Center, General Electric Co., Ph delphia, Pa. 19101.

GENERAL ELECTR

New MOL data
USAF astronauts surpass expectations in complex 15-day G-E "space flight"



MISSILE AND SPACE DIVISION GENERAL ELECTRIC

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Northrop Advocates Parachute Landing System for Mars Voyager

DESPITE SOME NASA opinions to the contrary, Northrop Ventura Division investigators have concluded that parachutes can lower *Voyager* landing vehicles safely to the surface of Mars, even if the most pessimistic estimates of the low density of the Martian atmosphere are accepted.

Having completed a preliminary study of the problems and possibilities, Northrop parachute specialists will now mark time until the *Mariner* program and other projects yield a better idea of the density of the red planet's atmosphere.

Density is the critical factor in determining whether parachutes will be suitable for the job. The so-called W_1 Martian atmosphere recently calculated for Jet Propulsion Laboratory by Dr. Gerald Kuiper of the University of Arizona is less dense than previous estimates by nearly a factor of 10. Density at the surface is set at about two percent of the value on Earth, and pressure is about one percent of Earth sea-level atmosphere.

The conclusion led some observers to decide that a Mars parachute would have to be unacceptably large to permit the five-minute minimum descent NASA wants to probe the vertical structure of the atmosphere. It also seemed likely that aerodynamic deceleration from entry velocities which might be as high as 29,000 fps and at angles as steep as 90° would be difficult or impossible.

To those who hold these views, retro-rockets look like the only answer. The Northrop scientists and engineers, who have supplied the ring-sail recovery parachutes for *Mercury, Gemini* and *Apollo,* insist that parachute descent on Mars is not only feasible but that it can be done more reliably and for less weight than by retro-rocket.



ENTRY and parachute deployment sequence of Voyager Mars capsule as envisioned by Northrop Ventura engineers: mortar ejects drogue chute; aft heat shield separates from capsule, deploying main chute; chute disreefs and lowers capsule to Martian surface.

● **Parachute weight advantage**—Northrop hopes to sell variations of the successful ring-sail for the Mars job. It is envisioned as a two-stage system—one relatively small supersonic-opening chute to stabilize and decelerate the vehicle during the final part of the Mars atmosphere entry, and a larger subsonic-opening chute cluster for the descent to the surface.

The supersonic drogue chute is estimated to be eight times lighter than a retro-rocket for the same job, and the rocket decelerator would pay the additional weight penalty of an attitude-stabilization system, which would be unnecessary in an aerodynamic decelerator.

Inflated ballutes have been considered as a means of aerodynamic entry braking and stabilizing. Northrop parachute designers regard them as too heavy for the amount of drag they supply, particularly if it turns out that they must be made of René 41, or some other metallic mesh material capable of resisting heat.

They hope to use HT-1, a special heat-resistant nylon, for their proposed parachutes. There may be serious drawbacks to the use of any nylon composition. Ionizing radiation during a long mission may cause a degradation of strength, and out-gassing of moisture in a vacuum may have similar effects. The water content of nylon is small, but it contributes to the strength of the material.

● **Nylon promising**—The lightest fabric permitted by the environment should be used to minimize weight. *Apollo* ring-sails, which face dynamic pressures of 64 psf at opening, are made of nylon that ranges in weight from 1.1 oz./yd.^{2} to 2.25 oz./yd.^{2} The lightest nylon available is 0.6 oz. The supersonic drogue will probably have to be

deployed at a very high altitude, where the Martian atmosphere is extremely rarified. Dynamic pressure may be low despite high entry velocity. Lightweight materials may therefore be acceptable. It might even be possible to use silk or Mylar.

Mission profile studies indicate that the maximum deceleration loading on the vehicle will occur before the drogue chute opens. It should be a high-drag body, probably shaped something like the *Apollo* Command Module, but with an even lower ballistic coefficient.

The Command Module has 50 lbs. of mass per square foot of frontal drag area. For a *Voyager* Mars lander, the goal is about 5 psf. The ballistic coefficient finally chosen may involve a trade-off with parachute efficiency. If the frontal area of the lander is made too large, the wake effects could impose a requirement for an unacceptably large parachute.

The minimum speed for deployment of the supersonic drogue has been set at Mach 1.5, since the high-drag shape becomes unstable at transonic speeds. The maximum is set at approximately Mach 4.6.

Flat-topped "Hyperflo" parachutes have been tested successfully at high Mach numbers but need further development. Since there would be a high-g load upon the vehicle at that point because of its own drag, a heavy mortar would be needed to get the drogue out of its compartment. The weight of this would be likely to force acceptance of a lower deployment Mach number.

• **Cluster configuration likely**— Ring-sail parachutes for the final descent of a *Voyager* Mars lander would probably be used in a cloverleaf cluster of three as in *Apollo*. An equivalent single canopy would be a third lighter, but the cluster assures reliability. The weight of a reserve chute as a back-up for a single canopy would offset its advantage in drag per pound of weight.

Reliability is one of the main claims made for the many-pancled ring-sail. It can sustain a tremendous amount of damage without much degradation of performance.

In the case of the *Mercury* ring-sail, it was found that with 30% to 50% of the panels destroyed it could still provide an allowable descent rate.

The ring-sail has one valuable characteristic which even its designers did not foresee.

When deliberately overstressed during a test drop, the canopy split from skirt to vent and performed what Northrop engineers have come to call a "snake dance." The canopy, spilling air through the split, turned itself completely inside out, re-formed and then repeated the cycle several times. The descent rate was within acceptable limits. ■

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Third Phase of MORL Study Has Ambitious Experiment Aims

Undertaking envisions a range of applications from weather observation to geographic and ocean current surveys

by Russell Hawkes

MISSIONS DIRECTLY profitable to the economy will be the focus of *Manned Orbital Research Laboratory* (*MORL*) study Phase IIb just awarded to Douglas Aircraft Co.'s Missile and Space Systems Division by NASA's Langley Research Center.

A sketchy look was taken at such applications as a manned orbiting weather station, geological and geographic survey, ocean current survey, crop prediction, operational support of future space programs, and manned orbiting observatories as part of the recently completed Phase IIa.

The new $1.6 million, 11-month study is to determine whether the preliminary design of the lab has enough versatility to undertake such missions after its primary biomedical and environmental research jobs are complete —and to see what changes are needed to ensure that it does.

As in Phase IIa, contractors participating with Douglas on the study will be: Bendix Corp., working on stability and control systems; Hamilton Standard Division of United Aircraft Corp., environmental control and life-support system; and International Business Machines, data management and communications.

MORL can be launched 52 months from the time NASA gives the go-ahead. This is one of the conclusions reached in Phase IIa. So far, about $2 million of NASA money and some private capital has been invested in Phases I and IIa.

Coming in the wake of arguments by the National Academy of Science that Mars exploration should be the next step into space after the manned lunar landing, the 27-volume report on *MORL* study Phase IIa gives *MORL* a more tangible look than that of most advanced study concepts. The first goal set for *MORL* is to collect design data and planning information for manned interplanetary missions and other long-duration spaceflights.

A realistic hypothetical experiment program was drawn up and Douglas engineers have concluded that a six-man *MORL* could accomplish it in a little over a year. The lab could accommodate a maximum crew of nine or ten. At the time the study was started, a prime goal was the gathering of information on the effects on man of prolonged weightlessness. It was hoped that the study and earlier flight programs would eliminate every unknown except the reaction of man to long spaceflights.

Whatever the fate of *MORL* as a hardware program, Langley and Douglas officials are convinced that the intensity and breadth of the study give it value in all U.S. manned space programs. Douglas has evolved *MORL* to its present form from a "baseline" spacecraft design that was the best estimate of what it should be on the basis of what was known a year ago. An iterative design evolution and planning procedure called TOPSY (Test Operations and Planning System) was used.

- **Sample experiment program**—An actual *MORL* experiment program would be drawn up by NASA, but Douglas created a realistic sample program for preliminary design purposes. Starting with safety margins, weight restrictions and the assumed technological state of the art, Douglas established 91 representative experiments in an order of priority, a variety of crew compositions, a schedule of mission operations, and other families of design-controlling variables.

Each sample experiment was measured against 104 separate criteria. TOPSY computer programs tried every possible combination of these to determine their constraints upon the rate of experiment accomplishment. Design, crew complement and operational program were then modified step-by-step, seeking maximum relief of these constraints and maximum system utilization.

With a six-man crew, and allowing for necessary operational and maintenance chores, 16,700 experimental man-hours per year will be available. The experiment program is estimated to last 1.4 years and to require 22,000 experimental hours.

Optimizing the mixture of specialized skills among the six-man crew can have an important effect on the rate of accomplishment. At the end of Phase IIa, improved skill mixes were yielding about twice as many experimental man-hours per day as the baseline laboratory and crew, 70% utilization compared to the original 30%. Program officials believe 90% may be achievable.

Maintaining the optimum skill mix as project emphasis shifts would require rotation of two complete crews per year. Although the study includes a thorough work schedule for the purpose of the study, it is not really possible to make a detailed plan far in advance. Douglas engineers emphasize that it will be necessary to develop a real-time scheduling tool to adjust the actual experiment program intelligently.

- **Logistics**—A six-man crew will require about 40,000 lbs. of supplies per year, including 15,000 or 16,000 lbs. for experiments during the first year. The second largest requirement of the logistic pipeline will be life-support system expendables for the men. The system design is expected to make the spares requirement small.

During five years of use, the logis-

tic requirements of *MORL* are expected to rise as its missions shift from experimentation to the various Earth-oriented applications of study Phase IIb. Logistic systems would account for a third of the $2.5-billion total cost of the first year of operation, and about 44% of the $4.2-billion operations over a five-year span. For the same periods, lab operatings costs would fall from 35% to 21%.

The most economical way of handling crew ferry and resupply jobs is with a single-vehicle concept. Allowing for growth of logistic requirements, the best ratio of cargo to passengers in the combined carrier is about 5,000 lbs. per man rotated. Of the launch system and spacecraft combinations available for the job, *Titan III-C/Apollo* was found to have insufficient capacity and *Saturn IB/Gemini* to have an excessive ratio of cargo capacity to seats, so that the combination would have to operate with an off-design load.

● **Vehicle combinations**—The preferred choices were *Saturn IB/Apollo* and *Titan III-C/Gemini*—with the edge going to the former because it could meet the resupply and ferry requirements with fewer launches and is better designed for long-term storage in space.

Gemini would fit within the hangar compartment of the *MORL* as now designed to permit maintenance operations upon spacecraft subsystems accessible from the outside. This advantage, however, is unnecessary with an *Apollo* Command Module because all subsystems are accessible from the inside.

Under the Douglas logistic concept, the Command Module would be orbited with a detachable cargo module by a *Saturn IB* launch vehicle. After docking and transfer of personnel and goods, a crane mounted on the *MORL* would swing the modules to parking positions against the side of the lab to leave the docking adapter free to receive other vehicles or to make the hangar compartment available as a vacuum chamber for experiments.

● **Cargo possibilities**—Under the rules applied by NASA, Douglas will not be free to bid on cargo module contracts. It was necessary, however, to sketch out a 220-in.-long, 54-in.-dia. module design to analyze the influence of such vehicles on lab design and operational program. They can serve as much more than cargo containers. One could provide an experimental animal farm with all its own on-board systems without transferring expendables, subjects or personnel between the lab and the module.

Another might contain a large optical telescope for astronomical research or for geographic and geological surveys. Mounted at the docking adapter, it would be easily accessible and would amount to an extension of the lab's working area.

Many of the things needed to extend the duration or enlarge the capability of the laboratory could be drawn directly from a retrofit module parked alongside to minimize losses and hazards of handling. Among these might be electrical power and make-up oxygen for the environmental control and life-support system.

Based on present technology, the most likely source of electrical power would be solar cells. Average power drain is estimated at 6 kw for a maximum crew. However, the broad panels are heavy. As part of the *MORL* study program, AiResearch Div. of Garrett Corp. is working on preliminary development of a radiothermoisotope-energized Brayton-cycle generator.

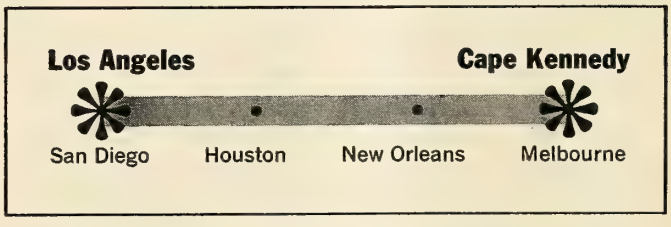
● **Weight and mission profiles**—The approximate lab weight for maximum mission flexibility is suggested by the fact that *Saturn IB* could put a 30,000-lb. lab into a low-altitude, low-inclination Earth orbit and a *Saturn V* could place a 32,000-lb. lab in a synchronous or lunar orbit. In Phase IIa, Douglas has hit upon a target weight of 28,000 lbs. for *MORL*, which will provide good adaptability and room for growth. Initial payload is figured at 9,200 lbs.

MORL is designed to be launched unmanned into a low-inclination (28.7-degree) Earth orbit by a *Saturn IB* launch vehicle, and then staffed by a crew of six to nine men after an orbital rendezvous and docking maneuver by the ferry-cargo vehicle. On-board systems would be adequate to supply the maximum crew for 90 days. Full duration and the planned resupply mission frequency are based on the nominal six-man crew.

A high-energy inclination or polar orbit would require more impulse than *Saturn IB* can provide. A two-stage *Saturn V* provides excess weight-lifting capability for an unmanned launch, but a cost benefit can be reaped by using a single initial launch with the crew inside a Command Module atop the lab. A three-stage *Saturn V* with an *Apollo* Service Module can place the lab in Earth-synchronous or lunar orbit.

Because of the long durations involved, safety is a prime requisite in the design of *MORL*. To get it, Douglas has used the structural criteria applied to the DC-8 jet transport instead of the more moderate ones usually applied to spacecraft. The ultimate safety factor is 4.0 rather than 1.5. Double walls are used, with an inner pressure hull isolated from thrust loads upon the outer shell. ■

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Low-G Accelerometers Await New Ground and Flight Test Developments

Potential customers unable to verify performance numbers; Air Force, NASA requirements could be met by single device

INABILITY TO VERIFY total performance capabilities of new very-sensitive, low-g accelerometers is now the biggest single obstacle blocking their use in current space activities and their refinement for several probable roles in advanced spacecraft.

The problem is two-fold: for one, accelerometers thought to be capable of sensing changes in acceleration levels as low as 10^{-8} g—and even 10^{-12} g—cannot be built with sufficient dynamic range for testing to those minimums in the relatively noisy, 1-g environment on Earth.

For another, the agencies which have supported development in this area have been unsuccessful thus far in finding room aboard satellites for these advanced devices—so they could be checked out in the only environment which is likely to yield the sought-after test and reliability data. There is no real urgency in this area, but planners are aware of the problem and are attempting to find a suitable spaceborne platform.

Lurking behind these two problems is the fact that despite widespread acknowledgement that very sensitive low-g accelerometers will be necessary for a host of future space missions, particularly those associated with electrical thruster systems, there are as yet no publicly approved NASA or Air Force programs firmly committed to the major systems these devices would support.

Main impetus for the work to date in low-g accelerometers has been, and continues to be, NASA (and to a lesser extent, AF) interest in various electrical propulsion schemes; AF interest in precise satellite drag measurements in low Earth orbit, and the realization that new instruments would be necessary to measure the fractional increments in g-forces which will be associated with virtually all of these missions.

● **Potential missions**—NASA scientists break down the electrical propulsion effort into three broad categories:

—High-thrust (10-15 lbs.), high-power (from the high kw to the megawatt range) nuclear-electric systems, such as those being studied by the Marshall Space Flight Center with an eye toward engine requirements for manned Mars and lunar ferry missions.

—Solar-powered systems which may possibly generate up to 20-50 kw of power and perhaps $\frac{1}{10}$ lb. of thrust, such as those being considered for unmanned solar probes and planetary orbiters. NASA's Jet Propulsion Laboratory has just received a number of responses to RFP's for a study of a new ion engine which could be applicable to a *Mars Orbiter*. This new study could add some fresh impetus to the low-g accelerometer field; however, planners caution that the new study "is just a sortie," to explore potential of solar-electric systems.

Accurate measurement of very low thrust levels and variations in thrust over long operating periods will be required for precise interplanetary guidance, orbital change measurements and optimum fuel utilization. Extremely sensitive devices, scientists say, might lead to thrust-vector alignment with these engines for real-time guidance trajectory control on interplanetary voyages and also provide some design leeway for use of gimballed electrical engine stuctures.

—Lower-powered electrical thrusters which extend from the wattage range up to about 5 kw and produce thrust measured from millipounds to perhaps hundredths of a pound. These systems on the lower-power end might be employed, for example, aboard NASA's *Applications Technology Satellite (ATS)*, or on the higher-power side, aboard the AF's *Manned Orbiting Laboratory*. NASA's Lewis and Goddard Centers are exploring engines in this range.

In addition to the need for low-g accelerometers in all of the electrical propulsion modes (with varying degrees of sensitivity required), they will also be considered for use as highly sensitive gradiometers aboard future NASA manned lunar-orbiting spacecraft to help profile lunar gravity fields and geophysical properties. Definition of NASA post-*Apollo* plans beginning in Fiscal Year 1966 should result in the award of studies to explore use of an accelerometer grouping to perform such missions.

Akin to its role as a gradiometer might be development of a system for use in attitude-stabilization systems as a local vertical sensor in Earth orbit which could operate independently of external references.

Among the uses which engineers say would rapidly be made of these devices—if they were available now on an off-the-shelf basis—with full-scale test and reliability histories, are greater use as low-orbit satellite drag sensors for highly refined orbital positioning, and perhaps in conjunction with small vernier thrust applications where "trimming" thrusting is used to position synchronous satellites, for example.

• **Test problems**—The testing problem basically boils down to this: when devices are tested in a 1-g field, the cross-suspension forces holding the accelerometer proof-mass and resisting the 1-g field inherently couple into the sensitive axis too large a measure of g-force to allow designers to see values as low as, say, 10^{-11} g along the sentitive axis. The best that can be done under current methods, both NASA and AF scientists told M/R, is down to about 10^{-4} or $^{-5}$ g, with extrapolation probably accurate to about 10^{-7}. Most accelerometer check-out at present utilizes measurements taken with a precision dividing head in a test-bed area located in relatively vibration-free "quiet" locations. NASA scientists point out that even in these locations, Earth noise and vibration can contribute on the order of 10^{-4} g.

To be able to verify performance claims of 10^{-11} g in a 1-g environment would require a device with a dynamic range of about 10^{12} g's—which is far beyond the current state of the art and likely to remain so.

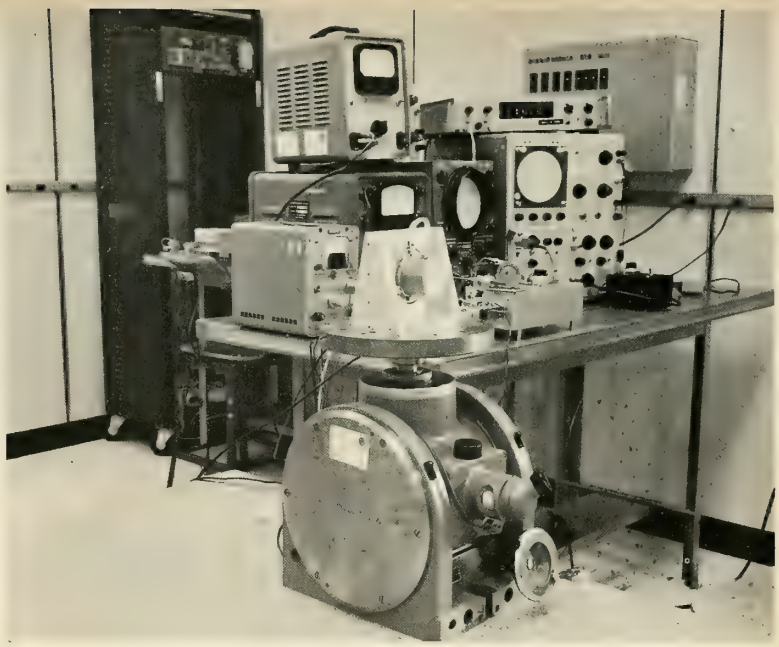
Several firms are now working in-house in an attempt to devise better ground-based test methods; similar work is being carried on by the Air Force at the Holloman Test Center and by NASA at Lewis Research Center.

NASA scientists at Lewis told M/R they have developed a new technique that they hope will reduce the noise problem considerably and allow at least a constant input to systems under test. They are reluctant to discuss the technique until they've tried it; this they expect to do within "the next few months." They will probably exercise the system with new prototype versions of an extremely sensitive electrostatic low-g accelerometer to be delivered to Lewis by Bell Aerosystems Co. in January.

• **Flight plans**—The effort to get some of these low-g devices aboard satellites for test has not yet met with any success. Scientists at Lewis had hoped to put the Bell units aboard the *SA-10 Saturn-1* launching, riding as a passenger on the large (3,400-lb.) *Pegasus* meteoriod detection satellite that *SA-10* is slated to orbit next year. The large size of the satellite would have allowed the accelerometer to be placed at a reasonable distance from the vehicle's center of gravity, and Lewis scientists say the orbit would have been an eccentric one with slow changes in attitude which would have given the units a good workout. However, NASA headquarters apparently has ruled against use of piggy-back type experiments with this satellite.

Attention is now focused at getting these devices aboard either the *ATS* or possibly one of the *OGO* series.

The major AF flight-test program for these devices probably will come as part of the *Manned Orbiting Laboratory* (*MOL*) program.



CLOSE-UP VIEW of an accelerometer mounted on a precision dividing head for a null-stability test at Bell Aerosystems Co. The instrument is resting on an eight-ton surface plate that is isolation-mounted.

In the interim, there is some AF interest in development of so-called drag-free or zero-g satellites which could be used as unmanned test beds. The Air Force, like NASA, is interested in finding out if any phenomena are masked during testing in a 1-g Earth environment which might show up in zero-g and prevent the sensing of very-small-acceleration levels.

A NASA contract with Stanford University is aimed at studying the development of zero-g satellites, and the Air Force is intent on following its progress. Some lab hardware is being developed.

• **Broad industry, narrow budget**—Though AF and NASA engineers both credit industry with a rather broad capability and some very clever schemes for low-g accelerometers, there is only one program which is now actively funded—the Bell MESA (miniature electrostatic accelerometer) device.

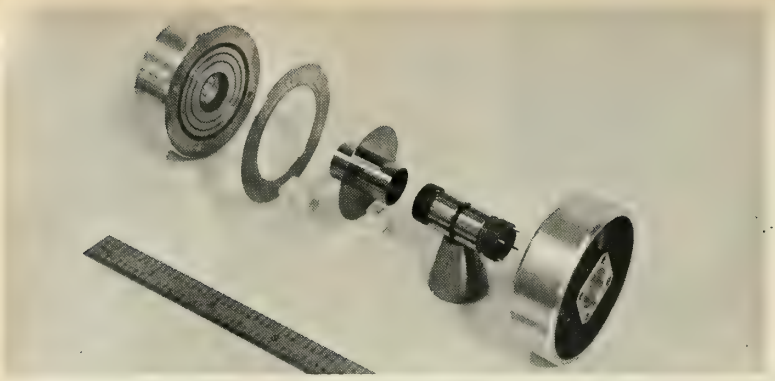
The amount of low-g accelerometer business to be done is not large. NASA estimates that a "big buy" probably would be on the order of $500,000 for "six or seven devices." While this business obviously could grow as other programs are added, it still should not amount to a great deal, and will be even less if it is split between several firms. This fact may be making some firms reluctant to go beyond the paper stage in development.

NASA scientists say candidly that firms which are aggressive and willing to put money into reducing some of these clever schemes to working hardware could walk off with most of the accelerometer business. They point out that if a single device is developed which yields the required sensitivities, it probably could be applied with minor changes for virtually any of the roles being suggested.

Though the Bell system appears to be farthest along that road at NASA, AF engineers at Wright-Patterson told M/R that their future mission requirements may be somewhat different, and they are likely to place heavy emphasis on cost and reliability factors in choosing accelerometers.

While Bell has put some of its own funds into MESA development, it has also been the benefactor of 3-4 years of Air Force support at Wright-Patterson (believed to be worth about $500,000), and most recently received a $228,000 NASA-Lewis development contract in August, 1963, for two prototypes (flyable) which will be delivered in January. The Air Force no longer funds the program, though it remains interested in the progress.

• **Bell's MESA**—The Bell device is a single-axis electrostatically suspended and electrostatically pulse-rebalanced accelerometer designed so that both the suspension and rebalance forces can be changed, or scaled, simply by changing the supply voltage levels. It is this feature NASA finds appealing.



BASIC MECHANICAL elements of Bell's MESA device are shown. The flanged cylindrical proof-mass is at the center. Carrier for the eight cross-axis support electrodes is at the immediate right. The cylinders at each end house the capacitance pickoff and force-rebalance electrodes.

With this capability and a large dynamic range of operation (10^6), the system can be suspended in a 1-g Earth field to permit adjustment and calibration during a launch-pad check-out and then programmed to reduce voltages, and therefore suspension forces, in orbit to a much lower value for measuring accelerations in space.

Bell scientists claim that the device will be capable of sensing a minimum detectable acceleration change to 10^{-12} g, which far exceeds the NASA specification, calling for a device capable of sensing 3 x 10^{-8} g.

The Bell device reportedly permits lowering the proof-mass suspension forces in orbit to about 10^{-7} g. According to Bell scientists, the cross-coupling effect of the suspension forces with the accelerometer's sensitive axis is on the order of 10^{-5} g. Therefore, they report, reducing the suspension forces in orbit to 10^{-7} g results in a null stability and repeatability from turn-on to turn-on of better than 10^{-12} g.

The cross-coupling of the suspension forces into the sensitive axis is the predominant factor affecting null stability and repeatability, and therefore affecting the minimum measurable acceleration. To lower the minimum detectable acceleration, the suspension forces must be lowered, which Bell claims can be most easily accomplished by means of electrostatic system wherein supply voltages can be easily changed within a single system.

Bell uses a capacitive-bridge pickoff system (similar to one used in a Bell digital velocity meter for the *Agena* space vehicle) to trigger a precise voltage time integral pulse every time the small cyclindrical beryllium proof-mass moves through a trigger position as a result of acceleration.

The mass is restored by the electrostatic forces derived from the voltage pulse, so that the digitized output of the device is a pulse rate proportional to the input acceleration, with each pulse signifying a discrete velocity increment. Bell says the scaling is flexible over a range from 0.0001 ft./sec./pulse to 0.1 ft./sec./pulse.

The proof-mass is the only moving part in the system, and Bell claims that since there is no suspension structure *per se* to damage, the limit of non-operating shock and vibration is set by levels which could permanently distort the proof-mass. These levels, say the firm, are in excess of any g's nominally experienced in a vehicle launching, and the accelerometer can therefore be fired non-operating into orbit without any subsequent deterioration. Depending upon launch environment and mission requirements the device could also be made to operate during launch with higher suspension voltages, designers believe. The electronics of the system have been qualified aboard *Scout* vehicles.

The total Bell system package, including the basic accelerometer and associated electronics (also including an oven for temperature control of sensitive components) weighs about 5 lbs. and consumes 15 watts of operating power and 5 watts of non-operating power.

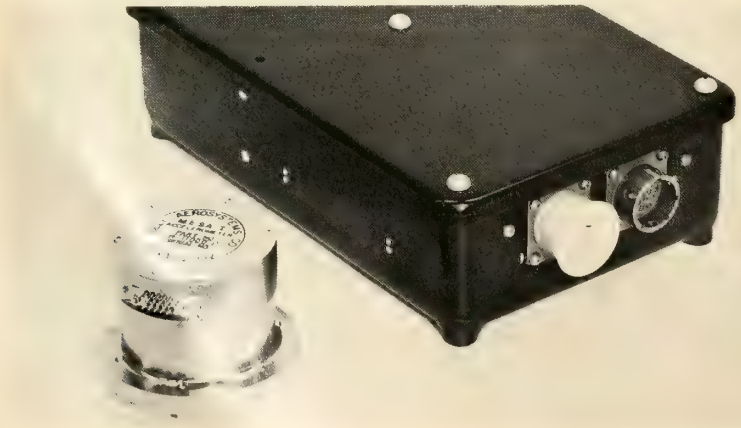
While no follow-on contracts are now planned, unless a program go-ahead is signaled in one of the potential user systems, Bell is known to be working on developing a three-axis version of the device and studying the application of microelectronics to the system.

● **Power savings uncertain**—Regarding further improvement in power demands for low-g devices, both NASA and AF engineers express some uncertainty as to whether or not it is worth the effort to attempt to develop micropower systems. They note that if these devices were to operate with a several-kw electrical propulsion system, for example, the power demand of the accelerometer would not impose any restraints. On the other hand, use of these with radioisotope systems might call for a significant low-power redesign. As one AF engineer expresses it, "while there is no longer a very conscious effort to reduce power further, low power in general implies high reliability."

● **AF interests**—At Wright-Patterson, AF engineers concerned with low-g accelerometers told M/R that all of the so-called programmable designs and free-suspension approaches (such as electrostatic, cyrogenic, and particle containment systems) are still of interest to the Air Force. But they point out that there are certain trade-offs with these systems, growing out of requirements for such things as extremely precise voltage controls and pulse measurements, which may argue for some other systems for particular missions.

For example, the Air Force in recent years has supported work at the Arma Div. of American Bosch Arma in development of a series of vibrating string accelerometers (M/R, July 9, 1962, p. 32) redesigned from initial high-g op-

MESA ACCELEROMETER package and associated electronics.



eration to also encompass various low-g applications. While these systems are viewed as relatively fixed in terms of operating range, they are also considered highly stable for whatever range they are designed for, and this direct force-to-frequency type of transducer yields perhaps the "purest" digital output.

Output characteristics of the various accelerometer approaches are extremely important because of considerations imposed by the various telemetry and onboard computer systems with which they will work.

Earlier this year, Arma delivered a new "Sub-Micro G" version of its vibrating-string series to Wright-Patterson. While details on the devices are classified, it is believed that they can operate at levels somewhere below 10^{-8} g. To get very low-g measurement from this approach generally requires enlargement of the accelerometer mass and modification of the vibrating strings.

Arma has taken the same basic device and modified the read-out system in a proposal submitted to NASA for use of the vibrating-string method as an orbiting gradiometer.

The vibrating string devices normally consist of two proof-masses supported by two or three so-called vibrating strings, which are actually very thin beryllium copper tapes under tension and in a magnetic field. The tapes' natural vibrating frequencies and changes induced by their motion in the magnetic field provide a measure of the forces acting on the proof-masses.

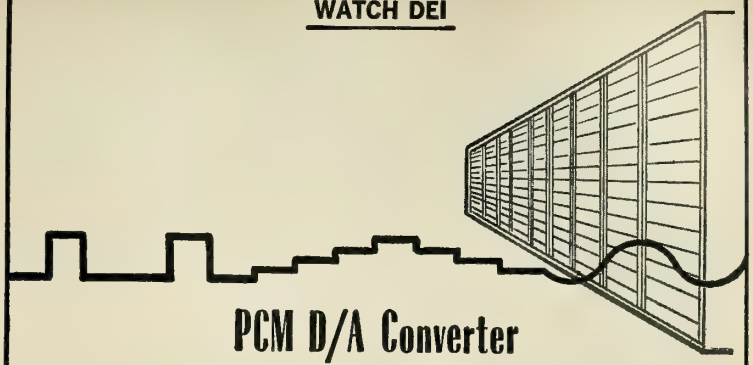
The Air Force will continue to look hard at devices which have the advantage of an uncomplicated digital output, and will also extend its efforts into development of new solid-state accelerometers using no moving parts and said to be somewhat "more exotic" than the vibrating-string approach.

An example of things to come may be found in the study recently completed for the Air Force by the Autonetics Div. of North American Aviation.

Autonetics has developed an approach to a cantilever beam accelerometer which uses a silicon bar with a tunnel diode doped into it to create a p-n junction on the surface. AF engineers explain that an external strain will cause the tunnel diode in the oscillator circuit to shift frequency. The dynamic range of the bar can be varied by shaving the bar very thin and enlarging the mass. The Air Force does not expect to extend the performance state of the art with this device, but engineers feel that this may be a good way to get useful low-g accuracies with improved reliability, low power, and low cost.

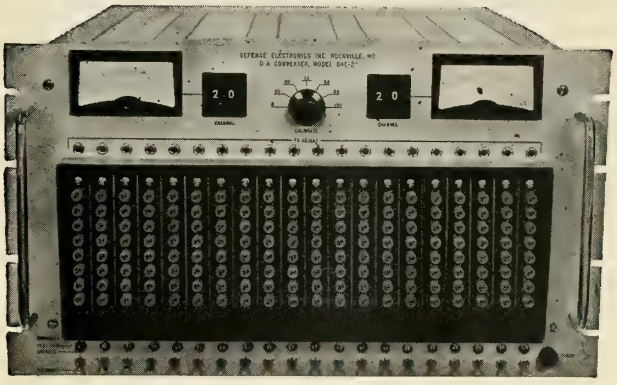
Engineers at Wright-Patterson say the results of the Autonetics study "looked good," and that some units might be built in the future. ■

WATCH DEI



PCM D/A Converter

New 20 Channel D-A Converter "Package".



- Self-Contained Calibrator
- Integral Binary Display
- Self-Contained Power Supply
- High Linearity and Stability

The new modular DAC-2 from Defense Electronics, Inc. offers linearity of ±.1% and overall accuracy of ±.25% for digital-to-analog data conversion in PCM sub-systems . . . plus a self-contained calibrator and power supply.

The compact unit has 20 eight-bit, digital-analog converter channels, each with its own integral binary display. Storage of data samples in each channel is shown by eight incandescent lights.

A versatile and flexible d-a converter "package", DAC-2 permits calibration of any one or a selected group of channels without disturbing operation of remaining channels. Monitoring of percent of full-scale and output voltages by front-panel meters is also provided. Thumb wheel switches select the channels to be metered.

Input of each module is eight data lines and one transfer line and output furnishes sufficient current for driving analog displays, recorders and galvanometers. The unit will operate at word rates up to 100kc.

Ask for the DAC-2 Bulletin . . . Watch DEI

DEI
RESEARCH
DEVELOPMENT
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Defense Electronics, Inc.

ROCKVILLE, MD. (301) 762-5700, TWX: 301-427-4660; SHERMAN OAKS, CALIF. (213) 872-2870, TWX: 213-732-2742; COCOA, FLA. (305) 632-5442; INT'L., ROCKVILLE, MARYLAND.

Circle No. 8 on Subscriber Service Card

GEC Camera Meets Needs of Saturn Test Monitoring, Lunar Exploration

Moon TV system is only one space-rated and approved by NASA; camera qualifies for wide variety of space and ground uses

by Charles D. LaFond

GARLAND, TEX.—An unusually rugged TV instrumentation camera developed here by General Electrodynamics Corp. has been designed primarily for operation in severe missile and space environments. So far it has not been applied operationally, nor are there any firm plans for its employment in the near future, except by engineers at Marshall Space Flight Center.

Tested at Huntsville by Marshall engineers for possible use in monitoring *Saturn V* engine tests, the tiny 10-lb. device met all requirements satisfactorily. Similarly tested by the U.S. Geological Service under simulated lunar conditions in Flagstaff, Ariz., for possible use by NASA lunar explorers of the future, it again successfully met all requirements. However, GEC was not even invited to bid on the recently awarded contract to supply portable TV monitors for the *Apollo* astronauts. The firm has submitted a bid to Boeing for the *Saturn V* flight-test application, but no award has been announced.

Except for a ½-in.-dia. hybrid vidicon, the camera system employs all-transistorized circuitry, occupying a total of 0.17 cu. ft. of space. The camera itself measures 2.5 in. in dia. by approximately 6 in. in overall length. Total camera weight is less than two pounds. The associated camera control unit weighs just over 8 lbs., and measures 5.5 x 6.5 x 4.75 in.

Operating on either 24-36 v dc or 105-125 v, 60-cycle ac, the system provides essentially a constant output from 10-10,000 ft.-candles of target illumination and a consistent 500-line resolution.

● **Lunar study**—Tests of the camera by Geological Service officials (June 8-12) were performed to determine astronaut mobility needs and problems that could occur in lunar-surface exploration. The study centered on use of a hand-held TV camera while performing geological investigations.

The USGS project for NASA was headed by E. M. Shoemaker. Terrain chosen for this experiment was at the Bonita Lava Flow, located in Sunset Crater National Park. A GEC model ED 6038 camera head was mounted on a staff directly under an inclinometer. The output cable was fed to the back pack on the "astronaut," which contained the control unit for his camera head, battery pack, and a small GEC-designed transmitter tuned to channel 6.



PRACTICALITY of portable TV for lunar geological studies was demonstrated with GEC system in simulation in Arizona.

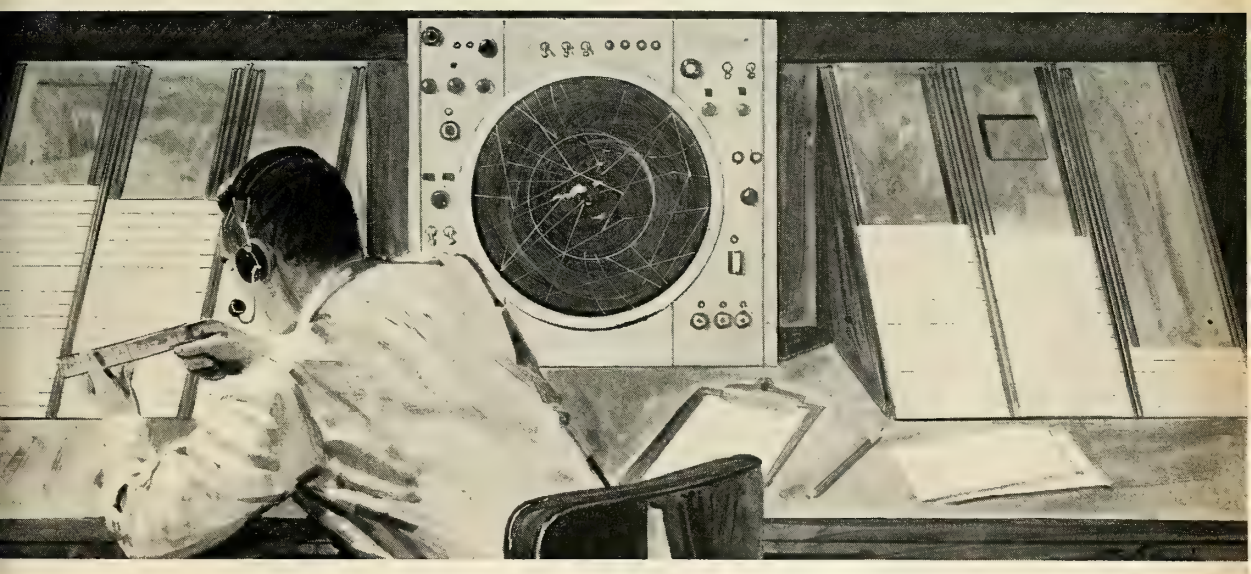
The particular GEC lunar television system was selected because it is the only space-rated and approved television system certified by NASA.

The Arizona lunar TV experimentation test is indicative of the fact that geologists and engineers someday will be taking their places alongside of the lunar astronauts. Part of the mission test or profile was laid out on the lava flow in such a way that the astronaut knew precisely where to walk. The pressure-suited operator, during the course of his mission, was required to notice peculiar rock formations. He then focused the television camera on this formation and explained in detail the structure of the rock to a geologist. The latter, in actual conditions, would be viewing a TV monitor in the *Apollo* Command Module, which would be orbiting the Moon while the astronaut was exploring the surface.

In the Arizona test, however, the simulated orbital vehicle was an Army van which housed monitor equipment. The mission profile continued for four days and at different times so that Sun, shadows, and other diurnal variations could be taken into account. Thus, it was possible to evaluate overall picture quality of the TV and for the geologists to determine their overall ability to analyze rock formations expected to be encountered on the Moon by TV means. The quality of the resultant pictures was extremely good, according to USGS and NASA officials, and it was shown that geological analyses could be made remotely.



FAA is upgrading area weather reporting



with a new Westinghouse picture transmitting system

Continuing its emphasis on greater air safety, the Federal Aviation Agency is conducting intensive R&D work to improve weather reporting. In an important step forward, Westinghouse is designing and building for FAA evaluation two prototype systems which will transmit ultra-clear weather pictures from remote radar sites to the air traffic control centers.

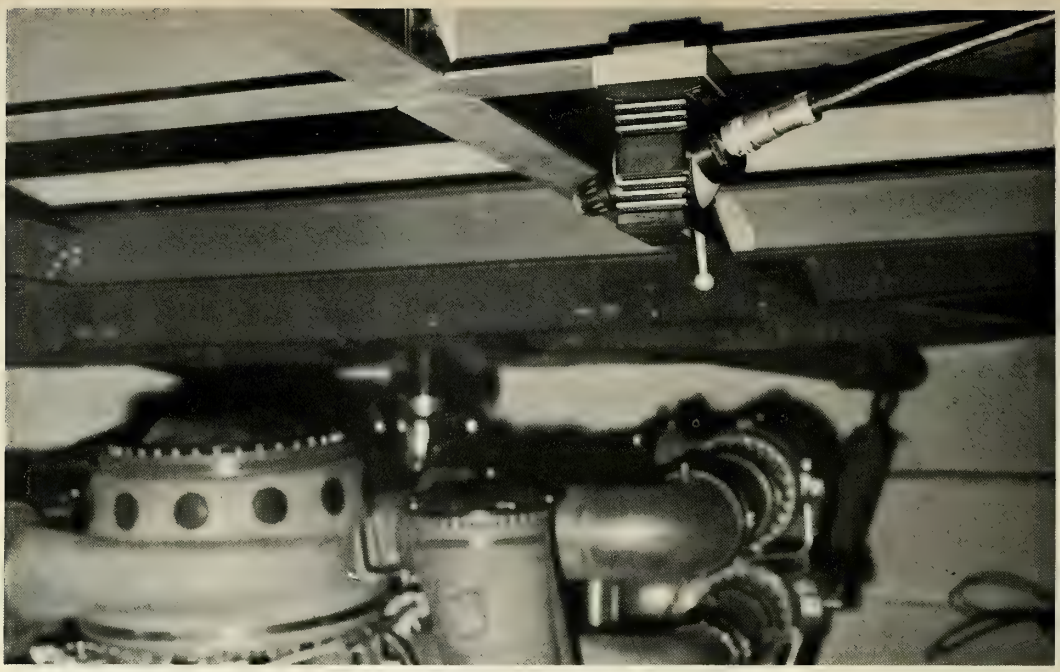
The new Westinghouse system compresses radar-detected weather signals from remote stations and transmits them to the control center over a conventional telephone line. In this manner a composite weather map of the region is instantly available to air traffic controllers.

Heart of the Westinghouse system is a vidicon type storage camera which is specially designed for slow scan or delayed readout applications. For the FAA system, readout will be on a two-minute frame basis, providing a brilliant, high-resolution image of slowly changing weather patterns on the air traffic controllers' displays.

The prototype systems, to be in operation at FAA sites on the East Coast by late 1964, represent a growing family of Westinghouse equipment for civilian aircraft and airport traffic control. These special-purpose systems are typical of Westinghouse capabilities in the design and manufacture of advanced electronic systems for defense and space. For information, write to Westinghouse Electric Corporation, P.O. Box 868, Pittsburgh, Pennsylvania 15230. J-02368

You can be sure if it's Westinghouse

Circle No. 9 on Subscriber Service Card



FOR BOOSTER MONITORING in static and flight tests, tiny TV camera is located just above engines.

• **Booster monitor**—Real-time monitoring by TV of large booster engines offers many advantages not obtainable by any other approach. The problem in the past, however, has been the severe environment—not just the temperature variations in close proximity to engines, but severe vibrations and g-loadings.

Photographic means have been used in the past, but damage to the film has been commonplace. Quality has generally been poor.

In May, 1963, GEC was awarded a $150,000 contract by Marshall Space Flight Center to build 15 TV systems for experimental use in big booster monitoring. The first was delivered in nine months and it successfully passed all environmental tests.

The remaining 14 systems, delivered during the next year, were then slated for more extensive lab tests (four units), and for use in monitoring static tests of the *Saturn* 1-C liquid engines (F-1).

ELECTRICAL SPECIFICATION FOR GEC TV INSTRUMENTATION CAMERA

OPTICAL	
Scene Illumination Recommended	10—10,000 ft. candles
Scene Illumination for Usable Pictures	0.5—1 ft. candle
Lens	8 mm "D" mount
Aspect Ratio, Height to Width	3:4
Color Response	Approximates human eye
ELECTRICAL	
Input Power	
With Converter	105—125 VAC, 60 cps
Battery Operated	24 to 36 VDC, 15 watts
Scanning	
Horizontal Frequency	15,750 cps
Vertical Frequency	60 cps
Interlace	2:1 30 fr/sec
Pick Up Tube	
1/2 IN. Vidicon, Electrostatic Focus	TD 1305
Resolution	500 lines
Grey Scale Reproduction	10 steps
Sweep Linearity	Better than ±1%
Keyed Clamp	Reduces low frequency interference Provides for constant black level
Sensitivity	0.5—1 ft. candle provides usable pictures 10 ft. candles provide 1.4 V PP composite
Automatic Target Control	
Constant Video Output	10—10,000 ft. candle input
Video Output	1.4 V PP into 75-ohm load
Sync and Blanking	Standard Broadcast EIA Optional 60-cycle line-lock operation
Voltage Regulation	Electronically regulated power supply holds picture stable over entire input range, 24 to 36 VDC
Sweep Protection	Sampling of yoke currents assures vidicon protection in the event of sweep failure or sweep amplitude reduction

• **Design objectives**—To meet missile/space test needs, the GEC system design provides a composite video output with standard EIA synchronization, a self-contained sync generator (capable of being locked to a 60-cycle power line), provision for a use of a separate sync generator, vidicon protection circuitry, automatic target voltage control, lower power needs and high reliability.

Provided with a stainless-steel, explosion-proof enclosure and specially designed lenses, the units have successfully survived up to 35-g random vibration and 60 g's for three seconds in each of three axes. Units are rated for at least 100-g shock over 11 msec.

As noted earlier, the GEC TV system is the only TV camera space-rated by Marshall SFC, and officials there are adamant in their praise for its operational performance.

Some of the units have been used in *Saturn-1* static tests. Others are awaiting completion of the big *Saturn* 1-C booster test stand at Huntsville before seeing operational use. Some of the cameras are slated for another space program not yet announced by Marshall.

Other tests experienced successfully by the cameras under a continuing study effort by Marshall included exposure in the horn itself of Marshall's large acoustic test system. There, the TV cameras were subjected to a continuous sound intensity of 185 db without any noticeable picture degradation.

For the future, MSFC engineers intend to subject one or two of the units to tests carried through to destruction,

just to find out what the equipment can actually withstand.

Electrical performance of the cameras is rated by MSFC researchers as "ideal."

● **Camera details**—The camera head contains a ruggedized 5.5-mm, F/1.8 lens housed in a special collet mount designed to maintain its initial focus setting and overall stability.

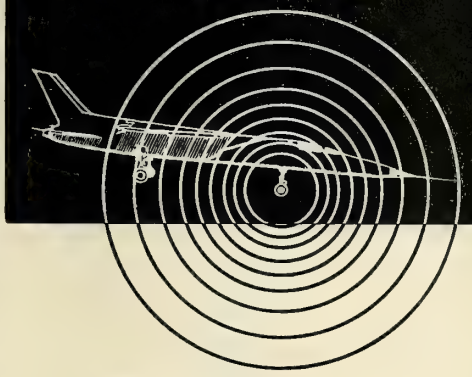
The lens images the object to be viewed onto the faceplate of a TD 1305A ruggedized half-inch vidicon which transforms the image into electrical signals. The vidicon preamplifier is a potted module that surrounds the vidicon tube immediately behind the faceplate flange. It boosts the video signal to a level sufficient for driving up to 150 ft. of camera control cable. Immediately behind the preamplifier module is a special totally encapsulated deflection yoke and filter module. This assembly fits tightly into the camera shell in such a manner that extraction and insertion of the vidicon tube can be easily performed without disturbing the remainder of the assembly.

The camera head, which is only 1½ in. in overall diameter, is provided with specially treated rings which mate with similar rings in the interior wall of the outer environmental sleeve for the purpose of damping out vibration, shock and noise—preventing their transmission to the main body of the camera.

For *Saturn,* and similar projects, the camera head and the environmental sleeve fit tightly inside an accurately machined aluminum sphere contained in the camera mount. In a typical installation, this mount is attached to steel struts in the booster engine compartment just above the flame shield. The camera, in a metal sphere, is swivelled into the optimum position for observing the object and is then locked firmly in place by means of a single lever seen on top of the mount. This requires no tools to mount, adjust or lock.

● **Other applications**—The GEC camera could be used on other space programs to monitor stage separation and is believed ideal for many ground applications where environmental conditions prohibit direct observation or the use of common commercial cameras. These would include blast-furnace monitoring, in areas of extreme noise or vibration. Certain other problems for which the camera may well be a solution include terrain surveillance from slow-flying aircraft or helicopters, monitoring control and test functions in conditions of high vibration such as prevail in the region of the pitch control mechanism of helicopter rotor blades, observation of control surfaces in supersonic flight tests, and relaying of instrument readings to ground observers without communications path errors. ■

Mud in your nose-wheel steering?

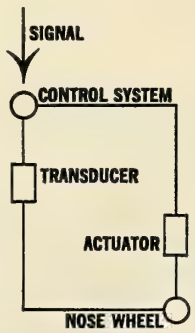


PROBLEM:
Adverse weather conditions cause faulty operation of the sensing potentiometer in the Nose-Wheel Steering. Mud, water, abrasive elements, noise and vibration cause serious inaccuracies in transmitting information.

SOLUTION:
G. L. Collins' A.C. or D.C. linear transducer! A complete system, including a sealed pick-off transducer for this application has been proven successful. This system will fit most current applications without redesign of the present housing. All friction, noise or environmental conditions are eliminated. The G. L. Collins transducer can be used in either A.C. or D.C. application.

EXPERIENCE:
Eight years of successful applications in Military and Commercial Aircraft. The G. L. Collins transducers are now being used on projects by North American Aviation, Chance Vought, and McDonnell Aircraft Corporation.

SPECIFICATIONS:
The system is designed for aircraft applications and is operational on 28 volt-400 cycles, or 24 volt D.C. ■ Transducer pick-offs are mounted with rod-end bearings ■ Infinite resolution and wide temperature ranges (—120° F to 400° F) ■ Large displacement measurements (Aircraft application: ± 1.5") ■ System designed to meet your specifications (Requirement of MIL-E-5272C)



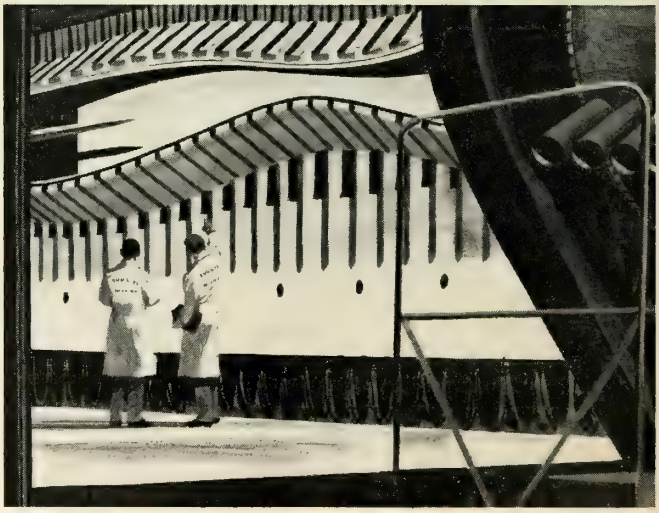
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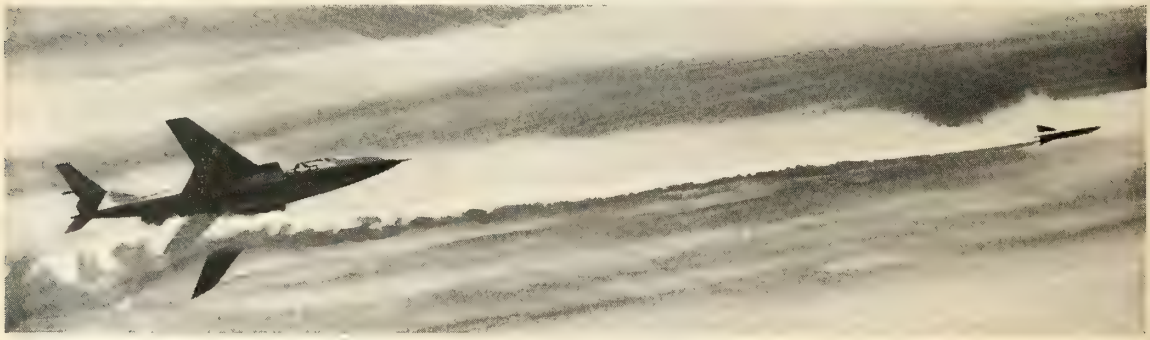
LOOK WHAT DOUGLAS IS DOING NOW!



NASA/DOUGLAS S-IV BECOMES WORLD'S HEAVIEST SATELLITE (19 TONS). Orbited earlier this year, the Douglas-built upper stage of Saturn 1 is the largest liquid hydrogen vehicle ever launched by the U.S. Its success means we're on target en route to the moon.



THE DOUGLAS AEROPHYSICS LABORATORY IS TESTING RE-ENTRY SHAPES in this and other wind tunnels. Studies apply directly to present and proposed defense and space programs. This Douglas facility can simulate speeds up to 23,000 miles per hour for research on such factors as heat and shear effects.



TO KEEP ON TARGET with new, more effective missiles, Douglas is exploring advanced techniques in relation to present tactical and strategic military problems. It is drawing on experience gained in producing more than 40,000 missiles relating to air-to-air, air-to-ground, ground-to-air and ground-to-ground missions.

DOUGLAS

MISSILE & SPACE SYSTEMS DIVISION

Mergers and Acquisitions

Amphenol-Borg Electronics Corp. directors have agreed in principle to the acquisition of Cadre Industries Corp., an Endicott, N.Y., electronics manufacturer, through a stock exchange of one share of A-B common for four of Cadre. Final acquisition is subject to Cadre stockholder approval, agreement on legal details and a year-end audit of Cadre. . . . *Belock Instrument Corp., College Point, N.Y., has acquired control of Republic Electronic Industries Corp. of Huntington, N.Y. REI recently received confirmation of a reorganization under Chapter XI of the National Bankruptcy Act. It manufactures Tactical Air Navigation (TACAN) and single sideband communications equipment.* . . . The Allegany Instrument Co. and MB Electronics, both divisions of Textron Electronics, Inc., have been consolidated. Allegany's test instrumentation operations will be moved from Cumberland, Md., to MB's facilities in New Haven, Conn. . . . *Ling-Temco-Vought, Inc., has offered to buy its common stock from persons holding 10 shares or less. The offer includes payment of brokerage fees and transfer taxes. The move is an effort on the part of LTV to save the cost of mailing dividends, proxy statements, annual reports and other literature to smaller shareholders.*

Missile/Space Facilities

Air Reduction Pacific Co., a division of Air Reduction Co., Inc., has dedicated a new air separation plant in Vancouver, Wash. In addition to missile/space requirements, the facility is to serve the food processing and refrigeration, metalworking, and shipbuilding industries. The multi-million-dollar plant can produce 160 tons a day of liquid oxygen, nitrogen and argon. . . . *Mesa Scientific Corp. has begun major expansion of its Pasadena, Calif., systems programming and other computer software facilities. The expansion follows the merger of Mesa's Inglewood, Calif., activities and the Systems Programming Corp. of Santa Ana, Calif. (M/R, Oct. 12, p. 41). Mesa provides the Jet Propulsion Laboratory in Pasadena with computer programming services.* . . . The Atomic Energy Commission plans to provide $3 million toward the cost of a cyclotron facility on the campus of the University of Maryland, College Park, Md. The University is to enlarge its physics building to accommodate the facility and will provide all needed funds in excess of the $3 million. . . . *Sylvania Electric Products, Inc., has announced plans for construction of a $750,000 metallurgical building in Towanda, Pa., containing 59,325 sq. ft. of space. The new building will be an addition to Syvania's Chemical and Metallurgical Div. and is to be completed by September, 1965. The Chemical and Metallurgical Div. is a basic manufacturer of tungsten and molybdenum products, phosphors, chemical and semiconductor materials.* . . . Dow Corning Corp., Midland, Mich., has completed construction of a technical service and development laboratory designed to serve the wire and cable industry. The lab will be used to develop and evaluate insulating materials, to study new production techniques and to offer technical service and training to wire and cable companies.

In the Courts

Sperry Gyroscope Co., which won a Federal court "piracy" judgment against National Semiconductor Corp. in October, has brought attachment proceedings against the firm in Connecticut Superior Court. Sperry says that NSC has not posted the $500,000 bond stipulated by Connecticut Superior Court following the Federal court decision that NSC personnel had brought to the Danbury, Conn., firm certain trade secrets from Sperry, where they formerly worked. NSC announced plans to appeal the Federal court decision after it was announced, but Sperry said that to its knowledge no such appeal has been filed. NSC officials temporarily suspended normal shipping and operation after the attachment, but, according to the firm, resumption of shipments was made possible by a court order based on a stockholder petition for protection of NSC against the attachment action. . . . *Technical Measurement Corp., New Haven, Conn., has filed a patent infringement suit against Nuclear-Chicago Corp. of Des Plaines, Ill. TMC charges that N-C is manufacturing a computer that infringes upon TMC's patented multi-purpose Computer of Average Transients used in medical laboratories to study human responses. TMC has asked for a "preliminary and final injunction against further infringement by defendant and those controlled by defendant; an accounting and judgment for damages arising out of defendant's infringements; an assessment of costs against defendant and an award of reasonable attorney's fees to plaintiff; and such further relief as the Court may deem proper."*

Potpourri

Indiana University's Aerospace Research Applications Center has announced a new pricing policy providing three price levels for its R&D services to various sized companies. Lowest annual fee will be $750 for a basic services package, intended primarily to meet the needs of small business. The smallest full service fee to limited points in a company will be $1,500. For larger companies, or those with extensive R&D programs, the cost will be $5,000 or more. . . . *The Rand Corp. of Santa Monica, Calif., has granted a license to Data Equipment Co. of Santa Ana, Calif., to produce a new digital computer and graphic input system. The rights to produce and market the man-machine communication device are non-exclusive.*

AWARDS

AIR FORCE

$9,000,000—**TRW/Space Technology Laboratories,** Redondo Beach, Calif., to produce within the next two years a space ground link subsystem (SGLS) consisting of eight vehicle packages and a demonstration ground station.

$1,126,000—**Sperry Rand Corp.,** Great Neck, N.Y., for production of training materials for advance range instrumentation ships.

$1,000,000—**Aerojet-General Corp.,** Azusa, Calif., for a very large monolithic glass fiber plastic rocket motor case.

$515,000—**Yardney Electric Corp.,** New York City, to supply rechargeable silver-zinc batteries and cells to furnish up to three hours of emergency power in case of generator failure.

$232,700—**Martin Marietta Corp.,** Denver Colo., for engineering support for the *Titan II* weapon system.

$192,000—**McDonnell Aircraft Corp.,** St. Louis, for the *ASSET* program.

$182,000—**Delcon Corp.,** Palo Alto, Calif., for non-destructive test equipment.

$88,500—**General Motors Corp.,** Allison Div., Indianapolis, Ind., for solid rocket motor vehicle optimization.

$73,680—**Aerojet-General Corp.,** Liquid Rocket Operation, Sacramento, Calif., for *Titan II* engineering support services.

$52,375—**International Business Machines Corp.,** Bethesda, Md., for bioastronautics laboratory research tool study.

$49,723—**AeroChem Research Laboratories, Inc.,** Princeton, N.J., for determination of rocket parameters by ionization probes.

$41,500—**TRW/Space Technology Laboratories,** Redondo Beach, Calif., for statistical analysis of *Titan* propulsion systems.

ARMY

$3,797,442—**Eastman Kodak Co.,** Holston Defense Corp. (division), Kingsport, Tenn., to make various propellants and explosives.

$3,463,000—**PRD Electronics, Inc.,** Brooklyn, N.Y., for microwave calibration test sets.

$2,376,604—**Sperry Rand Corp.,** New York City, for continued assembly of *Sergeant* missiles at Salt Lake City.

$2,138,000—**North American Aviation, Inc.,** Columbus, Ohio, for continued engineering services on *Roadrunner* target missiles.

$2,079,483—**Radio Corp. of America,** Communications Systems Div., Camden, N.J., for a classified program.

$564,000—**Systron-Donner Corp.,** Concord, Calif., for frequency measuring instruments.

$492,000—**The Hallicrafters Co.,** Chicago, classified development contract for electronic equipment.

$469,970—**Northrop Corp.,** Anaheim, Calif., for engineering services for the *Hawk* loader transport.

$414,400—**Philco Corp.,** Newport Beach, Calif., for maintenance and rehabilitation of *Shillelagh* facilities.

$366,507—**Sperry Rand Corp.,** Salt Lake City, Utah, for modifications to *Sergeant* missile systems.

$66,122—**ITT Federal Laboratories,** Nutley, N.J., for engineering services and materials for subsystem alignment and repair of a transportable satellite communications terminal.

$42,000—**Raytheon Co.,** Andover, Mass., for repair parts for *Hawk* missile system.

NAVY

$9,085,438—**Sperry Rand Corp.,** Great Neck, N.Y., for technical assistance and field engineering on navigation systems for *Polaris* missile firing submarines.

$8,120,000—**General Electric Co.,** Pittsfield, Mass., for repair and retrofit of *Polaris* MK 2 guidance system gimbal assemblies and inertial components.

$7,145,700—**The Bendix Corp.,** Radio Div., New York City, to provide continued maintenance and operation services at various sites on the Pacific Missile Range.

$5,100,000—**Interstate Engineering Corp.,** Interstate Electronics (subsidiary), Anaheim, Calif., for the development and production of *Polaris* operational readiness instrumentation.

$4,449,000—**Radio Corp. of America,** Communications Systems Div., Camden, N.J., for classified electronic equipment.

$1,775,000—**Honeywell Inc.,** Seattle, for the first large-scale application of microelectronics to a major communications program.

$1,621,100—**North American Aviation, Inc.,** Anaheim, Calif., for manufacture of a *Polaris* navigation training center for the United Kingdom.

$1,515,753—**Western Electric Co.,** New York City, for continued engineering work in support of the *Terrier, Tartar* and *Talos* programs.

$388,006—**Vitro Corp. of America,** Vitro Laboratories Div., Silver Spring, Md., for engineering services and studies related to ASW fire-control systems.

$243,349—**McLaughlin Research Corp.,** New York City, for services to monitor, analyze and report on *Polaris* repair parts program management plans.

$125,000—**Lockheed Missiles & Space Co.,** Sunnyvale, Calif., for deep launch test of the *A-2* and *A-3 Polaris* missile.

$95,000—**Bunker-Ramo Corp.,** Defense Systems Div., Canoga Park, Calif., for a hybrid computer study that may define the standard Navy computer of the future.

$71,385—**Del Mar Engineering Labs,** Los Angeles, for tow target launchers.

$45,000—**New York University,** New York City, for extension of a term contract for research and development of explosive liquid monopropellants.

$28,900—**Lear Siegler, Inc.,** Laser Systems Center, Ann Arbor, Mich., for laser range and bearing system.

NASA

$1,187,828—**Consolidated Systems Corp.,** Pomona, Calif., to design the technical systems for an extension to the Components Test Facilities at Marshall Space Flight Center.

$466,000—**Sylvania Electric Products Inc.** New York City, to design and develop a "counterspun" antenna for an advanced technological satellite that will spin like a gyroscope as it circles the Earth in a 22,000-mile-high orbit.

$375,241—**Douglas Aircraft Co.,** Santa Monica, Calif., for preliminary design of an integrated isotope power supply for *MORL*.

$365,000—**Ling-Temco-Vought, Inc.,** Dallas to test *Apollo* and *Gemini* prototype spacesuit assemblies in a vacuum under extreme heat and cold.

$242,141—**Northrop Corp.,** Hawthorne, Calif., for study of man's physical capabilities on the Moon.

$103,300—**Radio Corp. of America,** Princeton, N.J., for miniaturized single camera AVCS.

$96,000—**University of Chicago,** Chicago, for cosmic ray electron experiment, associated equipment and support for *OGO-E*.

$90,861—**Borden Chemical Co.,** Philadelphia, for separators for silver oxide zinc and silver oxide cadmium cells for spacecraft.

$67,607—**Motorola, Inc.,** Scottsdale, Ariz., for *Apollo* up data link system.

$67,500—**TRW/Space Technology Laboratories,** Redondo Beach, Calif., for spherical electrostatic analyzer experiments.

$65,178—**General Atomic Div., General Dynamics Corp.,** San Diego, Calif., for study of collisions of Electrons and ions with hydrogen atoms.

$45,252—**Bell Aerosystems Co.,** Buffalo, N.Y., for technical representative services.

$34,600—**Radio Corp. of America,** Astro-Electronics Div., Hightstown, N.J., for data correlation and model development.

$33,355—**Westinghouse Electric Corp.,** Baltimore, for *Ariel II* post-launch data analysis.

$31,700—**Airborne Instruments Lab.,** Deer Park, N.Y., for planetary (Mars and Venus) ionospheres study program.

$25,000—**J. J. Freeman Associates, Inc.,** Silver Spring, Md., for ionospheric refraction study.

INDUSTRY

$7,000,000—**General Precision, Inc.,** Link Group, Palo Alto, Calif., from **Grumman Aircraft Engineering Corp.,** Bethpage, N.Y., to design, develop and produce a LEM mission simulator.

$3,800,000—**Radio Corp. of America,** New York City, from the **Grumman Aircraft Engineering Corp.,** Bethpage, N.Y., for the descent engine control assembly for the LEM.

$1,000,000—**International Harvester Co.,** Solar Div., San Diego, Calif., from **North American Aviation, Inc.,** Rocketdyne Div., Canoga Park, Calif., for heat exchangers to be used in the *Saturn V* space booster.

$550,000—**Varian Associates,** Palo Alto, Calif., from **General Dynamics,** Pomona Div., Pomona, Calif., for microwave tubes to be used in the *Terrier* and *Tartar* programs.

$313,980—**Radio Corp. of America,** Missile and Surface Radar Div., Moorestown, N.J., from **MIT Lincoln Laboratory,** Cambridge, Mass., for engineering services associated with the PRESS program.

$250,000—**Consolidated Vacuum Corp.,** Rochester, N.Y., from **North American Aviation, Inc.,** Atomics International Div., Los Angeles, to supply vacuum system and engineering for a nuclear testing facility to be built for the Atomic Energy Commission.

$184,725—**Radio Corp. of America,** Communications Systems Div., Camden, N.J., from the **Boeing Co.,** Seattle, for *Minuteman* provisional parts.

$165,000—**Electro-Optical Systems, Inc.,** Pasadena, Calif., from **General Precision, Inc.,** Link Group, Palo Alto, Calif., for the design and construction of a data-recovery subsystem for a spacecraft television ground data-handling system to support the *Surveyor* project.

$69,000—**Technical Operations, Inc.,** Becham & Whitley, Inc., (subsidiary), San Carlos, Calif., from **North American Aviation,** Space and Information Systems Div., Tulsa, Okla., to produce destructor assemblies for the *Hound Dog* missile.

$65,000—**Varo Inc.,** Garland, Tex., from **Sperry Rand Corp.,** Sperry Gyroscope Co., Great Neck, N.Y., to build static inverter systems for shipboard inertial guidance systems.

ATOMIC ENERGY COMMISSION

$1,400,000—**General Telephone and Electronics Corp.,** Sylvania Electric Products Inc., Hicksville, N.Y., for the production of fuel cores for two nuclear power generating plants including one in the Antarctic.

REQUESTS FOR BIDS

GENERAL PROCUREMENTS

National Aeronautics and Space Administration
Washington, D.C. 20546

NASA is negotiating with Space General Corp., El Monte, Calif., and Philco Corp., Aeronutronic Div., Newport Beach, Calif., for a study of a survivable capsule for the lunar survey probe. For information only; RFP not available.

Purchasing Office
George C. Marshall Space Flight Center
Huntsville, Alabama 35812
Attn: Mr. J. M. Stuart

Negotiations are being conducted with Aerojet-General Corp. for studies of meteoroid impact simulation by magnetic gradient particle acceleration techniques. This is a continuation of a previous study. For information only; RFP not available.

Lewis Research Center
21000 Brookpark Road
Cleveland, Ohio 44135

Negotiations will be conducted with General Dynamics/Astronautics, San Diego, Calif., for experimental and evaluation studies of a coaxial plasma gun accelerator. For information only; RFP not available.

Directorate of R&D Procurement
Systems Engineering Group
Research and Technology Division
Wright-Patterson AFB, Ohio

Negotiations to be conducted with Lesells and Associates, Waltham, Mass., for a continuation of research on acoustic emission in metals under stress. For information only; RFP not available.

Contracting Officer
National Aeronautics and Space Administration
Langley Station
Hampton, Virginia

Negotiations are being conducted with Ion Physics Corp., to expand the scope of an existing contract to include operational data tests to determine the operational limits of a micrometeoroid impact simulator. For information only; RFP not available.

Contracting Officer
National Aeronautics and Space Administration
Langley Station
Hampton, Virginia

Negotiations are being conducted with Control Data Corp., Minneapolis, for a theoretical investigation of information limits of scanning optical systems. For information only; RFP not available.

John F. Kennedy Space Center
National Aeronautics and Space Administration
Cocoa Beach, Florida 32931

Negotiations will be conducted during the month of December with the Chrysler Corp., Space Div., New Orleans, La., for operation and maintenance support for the *Saturn S-1B* program. Work will include updating of ground support equipment. It is suggested that small business firms or others interested in subcontracting opportunities in connection with this contract should make direct contact with Chrysler.

Directorate of R&D Procurement
Systems Engineering Group
Research and Technology Division
Wright-Patterson AFB, Ohio

Negotiations will be conducted for research and experimentation to evaluate various cryogenic cooling methods and components. Government research facilities and materials will be furnished and made available for use by contractor personnel. Last day for honoring requests for the RFP will be Dec. 16, 1964. RFP 20315.

National Aeronautics and Space Administration
Lewis Research Center
Cleveland, Ohio

Negotiations will be conducted with Lockheed Aircraft Corp., Missiles & Space Co., Sunnyvale, Calif., on a contract to provide services to ensure Lockheed-controlled aerospace ground equipment support of the *Fire II* mission. RFP due date Dec. 8, 1964. This notice issued for the benefit of prospective subcontractors with appropriate security clearance so that they may contact Lockheed directly.

National Aeronautics and Space Administration
Lewis Research Center
Cleveland, Ohio

LRC will negotiate with Lockheed Missiles and Space Co., Sunnyvale, Calif., on *Agena* loads, data and qualification tests of the *Agena* long shroud. RFP not available. This notice is issued for the benefit of potential subcontractors.

TACTICAL MISSILES

Extensive activity in the development of tactical missiles offers a variety of opportunities to engineers and scientists. Specifically, these opportunities are in the following fields:

MISSILE AERODYNAMICS

Conduct analytical and experimental studies to determine basic aerodynamic characteristics of advanced tactical missile designs. Establish propulsion system requirements using estimated aerodynamic characteristics.

FLIGHT DYNAMICS

Initiate and conduct advanced analyses in flight dynamics and dynamic behavior of closed loop systems with the aid of analog computers and dynamic flight simulators for determining advanced tactical missile design requirements.

DESIGN INTEGRATION

Conduct preliminary design integration studies including interface compatability, logic, information flow and power distribution. Conduct preliminary vehicle sizing with a working knowledge of trajectory analyses, propulsion performance and component design.

VIBRATION AND FLUTTER

Conduct vibration and flutter analyses of advanced tactical missile configurations. Develop advanced analytical techniques for determining vibration and flutter characteristics.

PROPULSION

Originate and conduct analyses of advanced tactical missile propulsion system including solid, liquid and hybrid rocket engines and air breathing systems. Investigate new propulsion concepts and determine applications for advanced tactical missiles.

GROUND SYSTEMS

Formulation of requirements and preliminary system design of automatic and semi-automatic electronic checkout equipment for missile and ground systems. Determine requirements for missile handling and service equipment including mechanical, electromechanical, electrical, and fluid systems.

ORDNANCE

Perform analysis, preliminary design and integration of warheads and conceptual mechanizations for fuzing systems for nonnuclear and nuclear warhead systems.

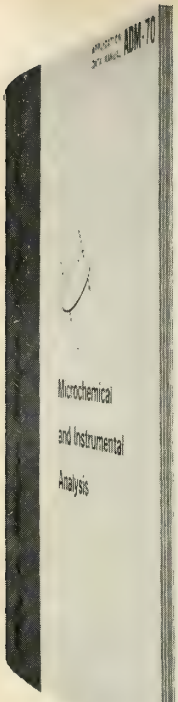
FLIGHT MECHANICS

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To arrange to visit our plant and discuss our programs, please write to: Mr. J. H. Papin, North American Aviation, Inc., 4300 East Fifth Avenue, Box MR-699, Columbus, Ohio 43216.

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names in the news


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William F. Lilley: Named manager of special products development of The Goodyear Tire & Rubber Co., Akron, Ohio. He will be responsible for development work for such products as missiles and fuel tanks.

Winfield E. Fromm: Named group vice president of the Airborne Instruments Laboratory Division of Cutler-Hammer, Deer Park, N.Y. In this newly-created office, Mr. Fromm will be responsible for a number of operating divisions and departments, including space systems and reliability.

David L. Coddington: Elected a vice president of Page Communications Engineers, Inc., Washington, D.C., a subsidiary of Northrop Corp. He will be in charge of system management, field services and technical documentation.

James P. Devlin: Appointed contract manager of the *Apollo* Instrumentation Ships program at General Dynamics/Electronics, Rochester, N.Y. This program will provide three highly instrumented ships to aid in the global network of tracking ships and stations to be used in NASA's Moon program.

Andrew J. Hayes: Elected to membership in the Financial Executives Institute. He is controllor of the Hydrospace Division of American Machine and Foundry Co., Cheektowaga, N.Y.

Carl Finger: Appointed as a mechanical design development engineer for Nuclear Data, Inc., Palatine (Chicago), Ill.

E. David Foreman, Jr.: Appointed corporate technical representative in the Southern California area of Atlantic Research Corp., Alexandria, Va. He formerly represented ARC in the Washington, D.C. area.

Robert G. Deissler: Selected to receive the Heat Transfer Division Memorial Award of the American Society of Mechanical Engineers. He is chief of the Fundamental Heat Transfer Branch at NASA's Lewis Research Center, Cleveland.

Albert E. Forster: Resigned as a member of the executive committee of Hercules Powder Company, Wilmington, Del. He is chairman of the board. **Edward G. Crum** was elected a vice president and a member of the executive committee. **Donald H. Sheffield,** member of the board and general manager of the Synthetics Dept., was appointed general manager of the Pine and Paper Chemicals Dept. to succeed Mr. Crum.

Dr. Leland K. Baxter: Appointed to the post of advanced project manager for Lockheed Propulsion Co., Redlands, Calif. He will be responsible for investigating new product areas for the California rocket firm.

C. Ronald Lowry: Named director of the newly-created Aerospace Industries Association Aerospace Technical Council. He will be responsible for the administration of AIA's technical staff.

Dr. Bruce H. Sage: Named editor of the *Journal of Chemical and Engineering Data,* a quarterly publication of the American Chemical Society. He is a professor of chemical engineering at the Californial Institute of Technology.

Dr. Howard Scharfman: Named to the newly-created post of manager, advanced planning, research and engineering, in Raytheon Company's Microwave and Power Tube Division, Waltham, Mass.

Malcolm P. Ferguson: Appointed a member of the Defense Industry Advisory Council. He is president of The Bendix Corp. Other promotions and changes in Bendix include the following: **Dr. Gerald A. Rosselot,** appointed vice president of engineering; **C. B. Sung,** appointed general manager and director of the Research Laboratoris division; and **Milo F. McCammon** and **L. E. Rasmussen,** appointed vice presidents and members of the corporation's administration committee.

James E. Cross: Elected secretary of the Institute for Defense Analyses. He was formerly Special Assistant to the Secretary of the Navy and to the Assistant Secretary for Research and Development from 1958 to 1961.

Richard D. Tutt: Appointed director of engineering at Industrial Acoustics Co., Inc., New York City. He will supervise commercial products research, development and application engineering departments.

—when and where

DECEMBER

Third Conference on Performance of High Temperature Systems, Huntington-Sheraton Hotel, Pasadena, Calif., Dec. 7-9.

Third Annual Western Contamination Control Congress, sponsored by the Western Regional Chapter of the American Association for Contamination Control, Lafayette Hotel, Long Beach, Calif., Dec. 9-11.

Symposium on High-Energy Astronomy, sponsored by Air Force Office of Scientific Research, Atomic Energy Commission, NADA, National Science Foundation, Office of Naval Research and the University of Texas, University of Texas, Austin, Dec. 26-31.

131st Annual Meeting, American Association for the Advancement of Science, Montreal, Canada, Dec. 26-31.

JANUARY

Eleventh National Symposium on Reliability and Quality Control, sponsored by the American Society for Quality Control and the Institute of Electrical and Electronics Engineers, Fountainebleau Hotel, Miami Beach, Jan. 12-14.

International Symposium on Solar Radiation, sponsored by the American Society for Testing and Materials and the Institute of Environmental Sciences, International Hotel, Los Angeles, Jan. 18-21.

Winter Meeting of the National Society of Professional Engineers, Jung Hotel, New Orleans, Jan. 20-23.

National Symposium on Hydrocarbon Analysis, sponsored by the American Society for Testing and Materials, Sheraton-Lincoln Hotel, Houston, Jan. 22-23.

Symposium on Fundamental Phenomena in the Material Sciences, sponsored by the Ilikon Corp., Sheraton Plaza Hotel, Boston, Jan. 25-26.

Joint Annual Meeting of the American Mathematical Society and the Mathematical Association of America, Univ. of Colorado, Denver, Jan. 25-30.

FEBRUARY

Reinforced Plastics Division Conference, sponsored by the Society of the Plastics Industry, Edgewater Beach Hotel, Chicago, Feb. 2-4.

Winter Convention on Military Electronics, sponsored by the Institute of Electrical and Electronics Engineers, Ambassador Hotel, Los Angeles, Feb. 3-5.

Unmanned Exploration of the Solar System, sponsored by the American Astronautical Society, the American Astronomical Society, American Geophysical Union, American Institute of Biological Sciences, Institute of Electrical and Electronics Engineers, and the American Institute of Aeronautics and Astronautics, Denver Hilton Hotel, Denver, Feb. 8-10.

Spring Meeting of the American Society for Testing and Materials, Statler-Hilton Hotel, Cleveland, Ohio, Feb. 8-12.

1965 Electrical and Electronic Trade Show, sponsored by the Electrical Representatives Club and the Electronic Representatives Assn., Denver Auditorium Arena, Denver, Feb. 15-17.

Sixth Annual West Coast Reliability Symposium, sponsored by the American Society for Quality Control—L.A. Section, and the University of California at Los Angeles—Engineering Dept., UCLA Campus-Moore Hall, Los Angeles, Feb. 20.

MARCH

Symposium on High Speed Testing, sponsored by Massachusetts Institute of Technology and Brooklyn Polytechnic Institute, Sheraton Plaza Hotel, Boston, March 8-9.

Aviation and Space Conference, sponsored by the American Society of Mechanical Engineers, Statler Hotel, Los Angeles, March 14-18.

Optical Society of America Meeting, Statler-Hilton Hotel, Dallas, March 31-April 2.



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Courage and Defense Economy

SECRETARY OF DEFENSE Robert McNamara's action in closing 95 military installations, pruning nearly half a billion dollars and 63,000 jobs out of the defense budget, was an act of political courage on the part of the Administration. Mr. McNamara and President Johnson, who has let it be known that he fully supports his Defense Secretary and is prepared to weather the political storms, are to be highly commended.

Mr. McNamara never has feared a fight and we are certain he is prepared to defend his action before the Congressional committees which will investigate it.

There is no question of the correctness of the step the Secretary of Defense has taken. The military establishment has a tendency to grow—and grow and grow—if strong efforts are not made to hold it within the necessary bounds. Unfortunately, such efforts are rare and usually ineffectual.

The pork barrel aspects of the defense budget become all too clear when the question of closing an installation arises. Politicians who are the first to call for economy at the Dept. of Defense also are the first to fight tooth and nail against any plan to close an installation in their constituency.

The overt political reaction to Mr. McNamara's announcement was entirely predictable and the Secretary was prepared for it. This fact does not, however, make things any more pleasant for him, particularly since he must soon face these same irate Congressmen with his Fiscal Year 1966 budget.

We are certain he must have welcomed the comment of Sen. Paul Douglas (D-Ill.): "This has been greatly needed for years. You are the first man to have the courage to do it." This is indeed the truth and we also applaud Sen. Douglas and those other members of Congress who were willing to stand up and say so.

The more general reaction was typified by Sen. Richard Russell (D-Ga.), who declared himself willing to support any action to reduce the staggering defense budget but immediately denounced the shutdown of an air base in Georgia as "totally unjustified."

Economy is in broad favor just so long as the economy is in someone else's backyard. It is this which makes it so difficult to prune surplus installations and jobs from the defense budget. Only someone of Mr. McNamara's determination could have carried it off.

The approach is typical of the devotion to cost reduction which the Secretary has shown since taking office. We frequently have criticized individual actions of Mr. McNamara in this regard but we are wholly in favor of his philosophy.

It should be noted that Mr. McNamara is losing the man he placed in charge of the Cost Reduction Program, the vary able Thomas D. Morris, Assistant Secretary of Defense (Installations and Logistics), who is resigning to return to private business. The achievements of Mr. Morris in the cost reduction area were exceptional, and certainly must go down as one of the highlights of Mr. McNamara's administration of the Pentagon.

The CR program was undertaken formally in 1962 with a goal of $3 billion in savings by 1967. Success of the effort can be judged by the fact that tradeoffs from cost reduction made it possible to hold the FY 1965 budget $2.5 billion under the amount which otherwise would have been necessary.

We have not always agreed with some of the actions taken in the name of cost reduction but there is no question that Mr. McNamara and Mr. Morris have done a great deal to bring some fiscal efficiency to the monolithic Dept. of Defense.

Mr. Morris himself has this to say in an interview in the current issue of *Armed Forces Management* magazine:

"I've spent my life in management and have seen many attempts to energize cost savings. But never in industry or government have I seen one program succeed on such a large basis. I attribute this to Secretary McNamara's extreme perception. Over a period of years the requirement for current reporting backed up by audit gave the program a sense of credibility and recognition to people and organizations and gave them an idea of interest of the President and DOD."

THE AUDITING SYSTEM which Mr. Morris mentions is of interest. In order to qualify as a genuine fiscal saving, each item must be validated by an auditor. There is, of course, the possibility that Defense Dept. auditors might be prejudiced in their evaluations—Mr. McNamara is aware of this possibility but the General Accounting Office turned down his request that GAO undertake the auditing.

Some of the savings are easy to identify, such as those resulting from the shift from non-competitive to competitive procurement and from CPFF to fixed or incentive price contracts. The economy of the base closings likewise is apparent.

Others are more marginal. Is it fiscal efficiency or engineering efficiency when it is discovered that the nuclear submarine George Washington does not require an overhaul which was scheduled and budgeted? DOD says it is a credit to the Cost Reduction Program. Others might argue the point.

But concerning the overall success of the Cost Reduction Program, there can be no argument. Mr. Morris will be missed.

Mr. McNamara likewise deserves plaudits for a job well done and we hope he will go on closing surplus bases just as fast as he can find them—regardless of the uproar from the Hill.

William J. Coughlin



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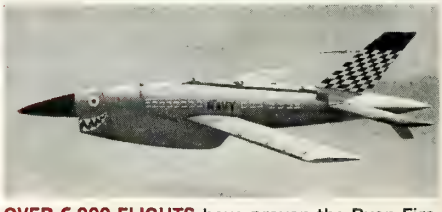
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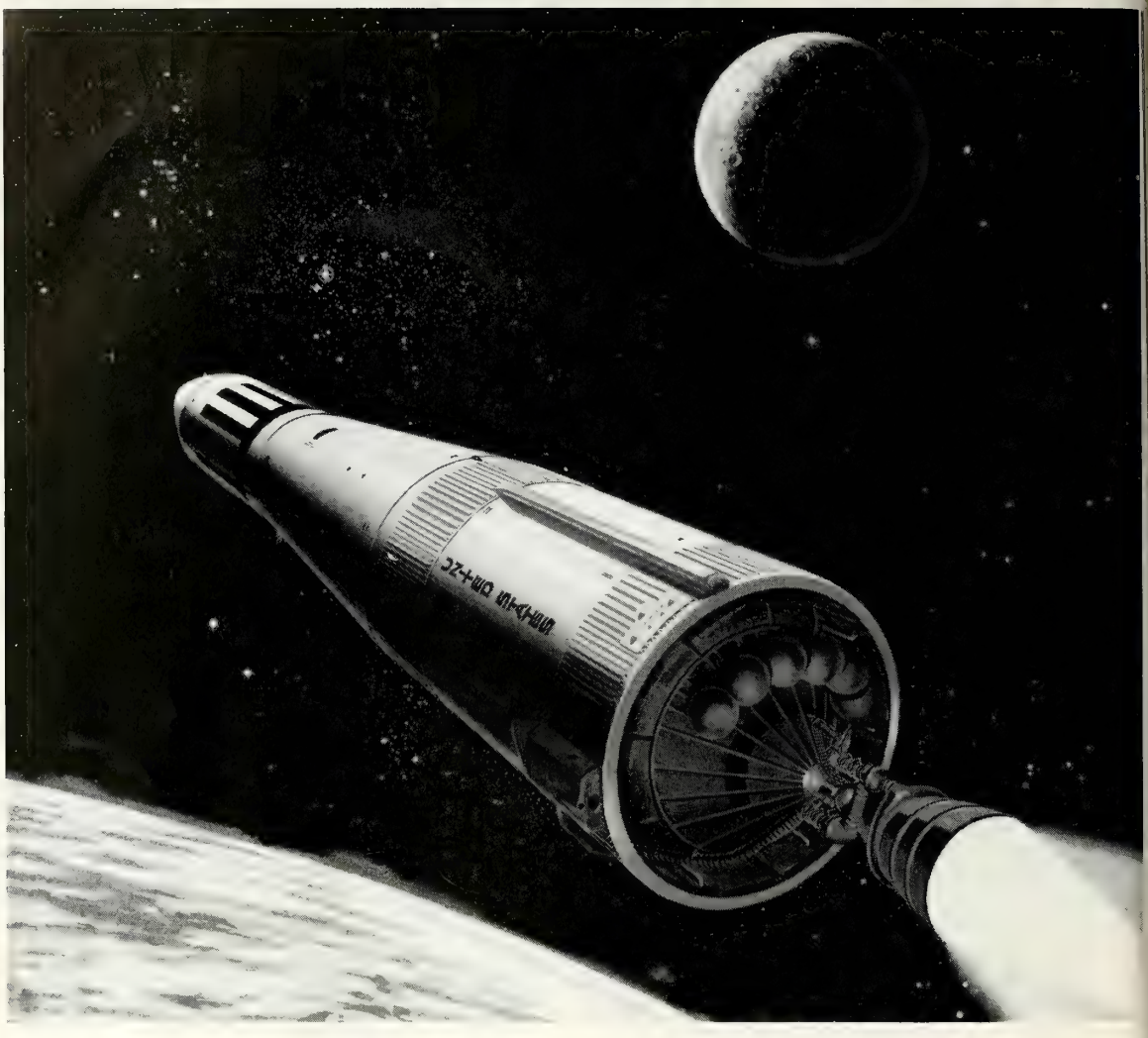
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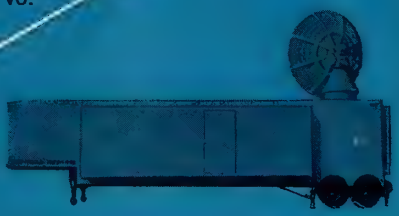
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Countdowns count on Bell System communications

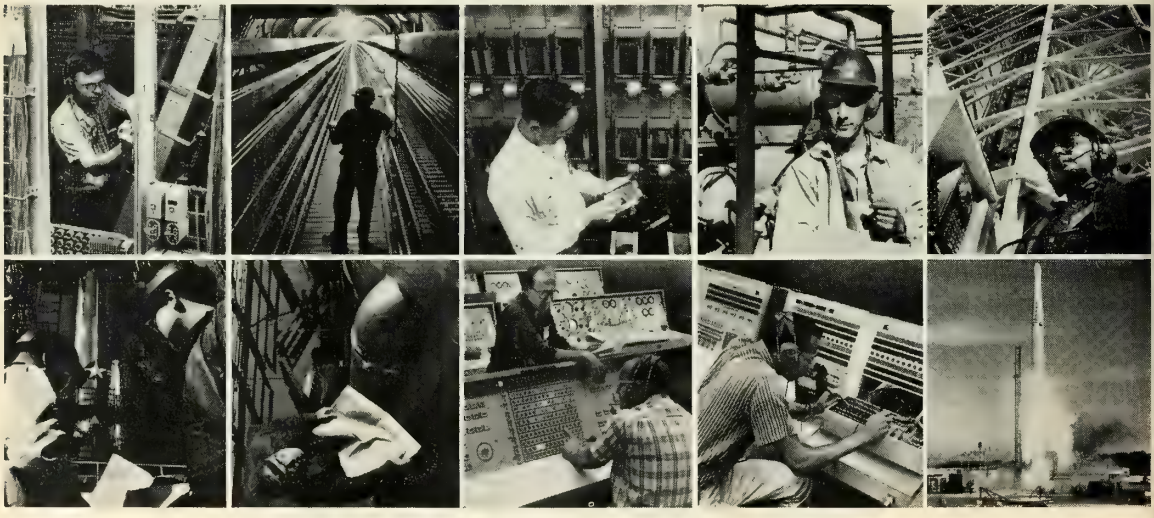
9 Countdowns start with a checkout of Bell System communications at the Air Force Western Test Range. Designed and built for the Air Force's Space System Division, the communications provide a rapid link between the many people and tasks involved in a rocket launch.

8 Control blockhouse connects with rocket launch pad by communications cables lying on shelves along walls of a long tunnel.

7 One touch of a button on a communications console in control room and this equipment will bring together widely scattered teams of rocket men involved in a task.

6 Fuel and liquid oxygen tanks stand at the ready to supply or retract rocket fuel as command post controls the launching operation.

5 Twenty communication posts stand so close to rocket itself that they're enclosed in steel and asbestos to keep from burning up.



4 Air Force rocket countdown is monitored by communications team right up to launch time.

3 Throughout launch area—in the enormous towers that nurse rockets into life—special communications stations have been installed.

2 As loading experts put fuel in a rocket, safety officer at the main control console can clear the area. By pushing buttons he blocks roads, blows sirens, controls traffic lights, stations guards and takes other precautions.

1 Through one earpiece of earphones worn by launch team controller, he can hear reports from 18 men. Through the other he may listen to any one of ten other groups that direct the work of 130 men.

Lift-off! . . . The communications system flashes rocket's lift-off signal to Pacific Missile Range Stations far at sea and relays rocket's flight position back to men in the launch control room.

Another example of how Bell System communications can be custom-designed to meet the special needs of the nation.

Bell System

American Telephone and Telegraph Co. and Associated Companies

missiles and rockets

THE WEEKLY OF SPACE SYSTEMS ENGINEERING

Volume 15, Number 24, December 14, 1964

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Published each Monday with the exception of the last Monday in December by American Aviation Publications, Inc., 1001 Vermont Ave., N.W., Washington, D.C. 20005. Cable Address: AMERAV.

Printed at Judd & Detweiler, Inc., Washington, D.C. Second class postage paid at Washington, D.C.

Copyright 1964, American Aviation Publications, Inc.

Subscription rates: U.S. and Possessions, Canada, and Pan American Postal Union Nations: 1 year, $5.00, 2 years $8.00, 3 years $10.00. All other foreign: 1 year $15.00, 2 years $25.00, 3 years $35.00. Air freight to Europe: 1 year $20.00, 2 years $30.00, 3 years $40.00. Single copy prices: regular issues 50 cents each; special issues $1.00 each. Subscriptions are solicited only from persons with identifiable commercial or professional interests in the missile/space industry. Subscription orders and changes of address should be referred to Circulation Fulfillment Mgr., Missiles and Rockets, 1001 Vermont Ave., N.W., Washington, D.C. 20005. Allow 4 weeks for change to become effective and enclose recent address label if possible.

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THE COVER



Little Joe II booster takes off from White Sands Missile Range, N.M., on Dec. 8, carrying unmanned boilerplate Apollo spacecraft with launch escape system attached. NASA officials said the test of the abort system was "almost letter perfect." (See p. 10.)

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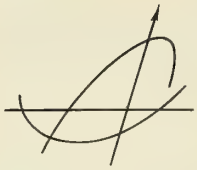
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letters

Manned Mars Mission

To the Editor:

Recently I came across a letter to NASA from an overseas correspondent. It was addressed: "James E. Webb, Administrator, NASA, Huntsville, Ala." Your article in the NASA issue dealing with the manned Mars mission ("Need for More Accurate Information Sets Planned Landing Back to 1985," M/R, Nov. 30, p. 69) lends further credence to the proposition.

Rushing to meet a deadline, a central bureau collating the activities of many field reporters is apt to cross its references occasionally. So, it should be explained that the "boxed" list of contractors in your article refers to the Future Projects Office at Huntsville and not to NASA as a whole. If the list were NASA-wide it would be substantially longer—the need for such studies was recognized early throughout the agency.

Notice that TRW Space Technology Laboratories is omitted from the box although the article states that Robert L. Sohn of STL undertook a Venus Swingby study under contract to the Future Projects Office at Huntsville. The Venus Swingby investigation in fact was part of a broad mission study by STL undertaken under contract to the Mission Analysis Div. of Ames Research Center, Moffett Field, Calif. Actually, two study contractors, North American Aviation's Space and Information Systems Div., under a separate contract, and STL were asked by Ames to examine the Venus Swingby possibilities, and both obtained positive results. To Mr. Sohn goes the credit for the discovery that the mode has general availability and is able to effect drastic reductions in Earth-entry velocity. There are other very important implications in respect of propulsive velocity increment and launch window that are unreported in your article and that add most substantially to the feasibility of the mode and the likelihood that it will ultimately become standard for the manned Mars mission.

Use of a close Venus passage can decrease departure velocity increments from both Mars and Earth and increase available launch windows so that Earth-orbital launch weight requirements are significantly reduced and launch operations eased.

Harold Hornby
Research Scientist
NASA Ames Research Center
Moffett Field, Calif.

Goddard Stamp Cover

To the Editor:

The good contacts we have with Mrs. Robert H. Goddard have led to the issuance by Dutch Space Travel Archives (DSTA) of a first-day cover for the postage stamp issued on Oct. 5, 1964, in honor of the late Dr. Goddard.

Enclosed please find a commemorative Goddard cover, which was serviced in The Netherlands. These envelopes have been cancelled on board the USS Albany (CG-10) during Mrs. Goddard's visit to Amsterdam, starting on the Oct. 5 date of issue.

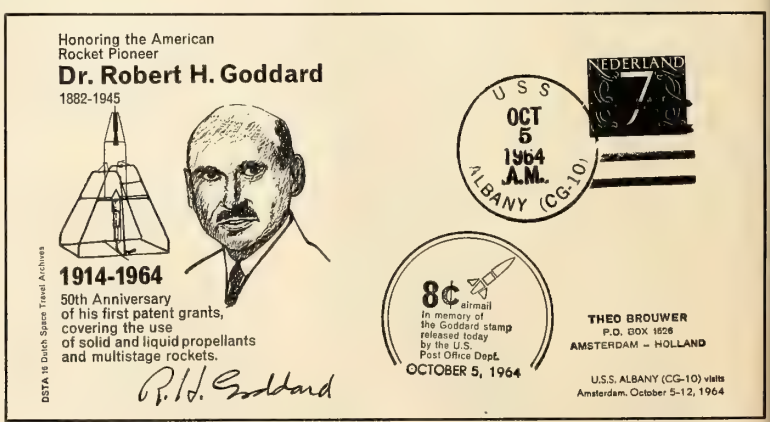
Only one thousand of these envelopes were serviced on board the American cruiser, and we received special permission from Mrs. Goddard to reproduce her husband's autograph.

We told Mrs. Goddard that most of the envelopes would be sent to space flight authorities.

We still have a number of envelopes available, and those of your readers who are interested in such a cover can send a request to DSTA. Provided every request is accompanied by one International Reply coupon, we will airmail a cover to those who ask for it. We send these covers free of charge.

This is the only cover issued outside the United States for the Goddard postal event.

Theo Brouwer
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REPRODUCTION of Dutch Space Travel Archives first-day Goddard stamp cover.

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ELECTRICAL SYSTEMS — Design and load analysis of aircraft electrical power generation systems. Experience in power factor and load balancing parameters.

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The Countdown

WASHINGTON

NASA Budget of $5 Billion or More Seen

Watch for White House approval of a NASA budget of $5 billion or more for the coming fiscal year. The space agency has requested $5.6 billion. House space committee members told COUNTDOWN last week they will fight any severe cuts.

No Defense Spending Increase Expected

Research, development, test and evaluation (RDT&E) spending at the Dept. of Defense may decline slightly from its present $6.5-billion level in the next fiscal year. DOD is trying to maintain its overall budget at $50 billion. Only way to achieve this without reducing force levels, in view of other mounting costs, is a cut in RDT&E. Both the Air Force and Navy already have sustained an across-the-board slash of their RDT&E budget submissions.

Future Remains Dim for MMRBM

It is almost a certainty that the FY '66 budget will not include money for an alternative to the *Mobile Mid-Range Ballistic Missile*. There still is no requirement for such a weapon and DOD seems to have learned its lesson about having requirements for weapons it wants to develop. The *Transportable MRBM* concept, although favored in some quarters, is making no progress with top decision-makers.

MLF Suffers Another Blow

Fixation of Defense and State Department officials for the creation of the multilateral surface fleet suffered a severe blow when President Johnson agreed to British Prime Minister Harold Wilson's idea of a broader-based, more inclusive tying together of NATO nuclear weapons. The President also agreed to ease off on American pressure seeking agreement on the force as soon as possible.

ComSat Gains a Point and Then Some

Announcement that Defense Communiations Agency will ask for ideas on the Advanced Defense Communications Satellite System from industry should cheer Communications Satellite Corp.—if it needs it. The government-created corporation was included in the list of firms to be solicited. ComSat has always made the point that it could develop a system for the military if asked. Until now, it was unclear whether this had gotten through to DOD. It appears it has, although there still is a long road before a development contractor or systems manager is named. Meanwhile, the phenomenal climb of ComSat stock continues to amaze Wall St.

Nike-X To Wait Another Year . . .

It now appears *Nike-X* will have to wait another year for pre-production funds. With the budget squeeze on, there will be no money in the '66 program for initial tooling. This also means a year's slip in deployment. Now the first battery could not be operational until 1970-71.

. . . While MAR Performs Well

Tests at White Sands Missile Range of the Multi-function Array Radar are surpassing all expectations. This has always been the critical component in *Nike-X*—some Defense officials have questioned whether it would work at all. Test results to date are making believers out of even the most adamant skeptics.

Navy Installing Digital System

The guided missile cruiser Albany is being outfitted at Norfolk, Va., with a new digital ranging system which could replace analog systems now in use in the fleet. Built by the Naval Ordnance Test Station, the digital system will undergo operational evaluation tests during the next several months.

DOD Going Into Publishing

A 32-page, monthly "Defense Industry Bulletin" will be published by DOD beginning in mid-January. Initial circulation is limited to 1,200 copies and the publication will cover contracting, management and other items of interest to industry. Before their consolidation at DOD level, each service information office put out a similar publication.

INDUSTRY

Uses Explored for Redundant ICBM's

Use of surplus *Titan I* ICBM's to launch research reentry vehicles apparently is being investigated by the Air Force. A *Titan I* was launched from Vandenberg AFB, Calif., last Tuesday in what the Air Force described as the first of a series of tests to determine the missile's compatibility with various payloads. COUNTDOWN is told the payload was a re-entry vehicle supplied by Avco Corp., an active contributor to the Air Force's *ABRES (Advanced Ballistic Re-Entry Study)* program. Emphasis on RV-type payloads is expected throughout the planned test series. Until now, the dominant launch vehicle for *ABRES* has been *Atlas*.

AIA Loses PR Director

H. M. (Hal) Connor has resigned as director of public relations of Aerospace Industries Assn. The departure will be effective Jan. 31. Col. W. S. (Pug) Evans (USAF, Ret.), deputy PR director, will serve as acting director until a successor to Connor is chosen. The resignation was said to be the result of a dispute with AIA President Karl G. Harr over the association's PR functions.

Agena Accuracy Impresses JPL

Jet Propulsion Laboratory is impressed by the improvement in guidance accuracy shown by Lockheed's *Agena D* vehicle. In 1962, an *Agena B* put *Mariner II* on a course that missed Venus by 233,000 miles prior to mid-course correction. In comparison, *Agena D* put *Mariner IV* on a course that missed Mars by only 151,000 miles before correction, even though the trajectory is twice as long as that of Venus.

INTERNATIONAL

Questions Arise on Voskhod Material

The repeated Soviet mention of confidence in the sealed cabin of the *Voskhod* spaceship is giving rise to speculation that the white porous interior covering identified as "porolon" may be a self-sealing plastic. It also is suggested that it may have radiation protection properties.

Delay Seen in French Satellite Launching

The French press reports that delays in the development of the first stage of the *Diamant* booster, which recently underwent its third unsuccessful test, may delay the launching of the first all-French satellite until the middle of 1966. Utilization of a solid propellant instead of the present liquid-propellant booster now is considered a definite possibility.

The Missile/Space Week

GT-2 Slips Into January

Damage sustained in an abortive launch attempt of the *Gemini II* unmanned space capsule Dec. 9 will necessitate postponing the next launch attempt until sometime in January.

The schedule slip will also affect the first manned *Gemini*, which will be launched about three months after *GT-2*. Most optimistic estimate for the *GT-3* launch is now late March or early April.

The cause of the engine shutdown that halted the *GT-2* launch only two seconds before lift-off was a hydraulic system failure that permitted one of the *Titan II* launch vehicle's gimballed engines to swivel the maximum 4 degrees. The movement triggered engine shutdown.

When the engine, which had reached 77% of efficiency, shut off, a coolant tube in the engine bell apparently cracked because of the rapid fall in temperature. Further damage, although not immediately assessed, appeared likely.

First LLRV Tests Complete

NASA Flight Research Center has completed the first series of flight tests of the Bell Aerosystems Lunar Landing Research Vehicle. During the next four or five weeks, the last two of its seven electronic packages will be installed and checked.

FRC engineers report that the initial flight-test program is progressing more rapidly than expected, but they do not plan to compress the program in order to deliver the flying simulator to Manned Spacecraft Center at Houston ahead of schedule. They would prefer to expand the program to include additional areas of experimentation.

The center has asked for a full year of experimentation with the LLRV. The Houston reply was favorable, but not formal. Program officials observe that the LLRV could simulate many non-aerodynamic spaceflight maneuvers in addition to the lunar landing for which it was primarily designed.

SNAP-8 Passes Test

The *SNAP-8* turbine alternator assembly (TAA) passed a successful 76-hour test in which mercury was used as the working fluid. The test demonstrated operational capability and machine performance up to 80% of its rated power, Lewis Research Center officials said.

Henry O. Slone, *SNAP-8* project manager at Lewis, described the results of the test as "significant" in the development of the space power generation system. The Aerojet-General Corp.-developed system will produce 35 kilowatts of power, and is expected to have a 10,000-hour lifetime.

Heat source for the turbine alternator test was a gas-fired heater instead of the nuclear reactor that ultimately will provide the energy source. Atomics International is developing the reactor for the Atomic Energy Commission.

Shots of the Week

An *Apollo* spacecraft boilerplate underwent what appeared to be a perfect maximum-aerodynamic-pressure abort test at White Sands Missile Range, N. M., Dec. 8. The canards (M/R, Dec. 7, p. 13) located near the top of the jettison tower and designed to damp descent oscillations prior to parachute deployment worked satisfactorily. The spacecraft tumbled eight or nine times after separation from the *Little Joe II* booster, but then lapsed into a 150-degree swing before the launch escape tower, boost protective cover and forward heat shield were ejected. Following ejection, the Command Module was completely stabilized by two drogue chutes. Deployment of the three main chutes followed and the craft touched down apparently undamaged. Three additional abort tests are planned in the current series. The next is to be a high-altitude test at 100,000 ft.

- The Air Force's *Athena* rocket on Dec. 4 made a successful flight from Green River, Utah, to a target area in the White Sands Missile Range, N.M.
- Preliminary reports indicated that an Air Force *Atlas F* ICBM fired from Vandenberg AFB, Calif., Dec. 4 landed on target in the Western Test Range.
- On Dec. 8 the Air Force successfully launched a *Titan I* ICBM from Vandenberg AFB, Calif.
- The Air Force on Dec. 9 fired two *Minuteman* ICBM's from Vandenberg. The first had to be destroyed by the range safety officer when it malfunctioned shortly after take-off; the second firing was a success.
- The Air Force successfully launched the fifth *ASSET* re-entry test vehicle in its series of six from Cape Kennedy on Dec. 8. Booster used was a single-stage *Thor*.
- NASA test pilot Milton Thompson on Dec. 9 flew the *X-15* rocket plane to an altitude of 91,000 ft. at a maximum speed of 3,545 mph.

Mariner Confidence Expressed

Scientists at the Jet Propulsion Laboratory were confident late last week that the *Mariner IV* spacecraft would pass within 5,400 miles of Mars next July 14 at approximately 2:10 p.m. EST.

JPL officials also told MISSILES AND ROCKETS that, based on present information, a second course correction probably would not be necessary, even though the capability for such a maneuver exists.

The confidence was expressed despite the fact that *Mariner IV* strayed from its guiding star, Canopus, Dec. 8, presumably because a speck of dust interferred with the spacecraft's sensitive Canopus seeker. This caused the sensor to lock onto another star, Gamma Vela, but the change did not significantly alter the spacecraft's trajectory.

ComSat Has Active Week

The Communications Satellite Corp. and interested communications firms have been asked to provide additional detailed arguments concerning ownership and operation of initial ground stations for the satellite communications system (M/R, Nov. 30, p. 137). The Federal communications Commission proceeding, called a Notice of Proposed Rule Making, may delay settlement of the issue until March, 1965.

After consideration of the ComSat petition for ground station control and replies from several common carriers, the FCC last week announced it found the proposed rule too limited in scope for "the task of establishing criteria governing the issuance of Earth station authorizations. . . ."

Accordingly, the Commission requested that interested parties comment on three possible courses of action: adoption of rules; adoption of a general policy; and an invitation to file applications for specific Earth stations. Comments are to be filed by Jan. 5.

Meanwhile, ComSat common

stock continued its fast pace on the New York Stock Exchange. It reached 66¼ points on Dec. 9 before the Exchange's Board of Governors halted trading for three hours to match up buyers and sellers.

In other action last week, the corporation issued RFP's to 16 companies for studies of launch vehicles for a medium-altitude communications satellite. Requests went to: Aerojet-General Corp.; Avco Corp.; Bell Aerosystems Co.; Bendix Corp.; Boeing Co.; Curtiss-Wright Corp.; Douglas Aircraft Co.; General Dynamics Corp.; Grumman Aircraft Engineering Corp.; Ling-Temco-Vought, Inc.; Lockheed Aircraft Corp.; Martin Co.; McDonnell Aircraft Corp.; North American Aviation; Republic Aviation Corp. and United Aircraft Corp.

Extended Pershing Denied

Army and Defense officials deny that an extended range *Pershing* is under development—as implied in a newspaper report from Bonn that the U.S. has promised to furnish the West German Army with a 750-mi. version of the weapon. "How could we have promised them that," one Defense official says, "when we don't even have such a weapon under development ourselves?"

Both the Army and DOD admit, however, that such an extended range *Pershing* is feasible and is part of the Army's "product improvement" plan. "We have proposed this to DOD," an Army official points out, "but only as part of our continuing product improvement program. There is no money in the budget to develop such a missile."

West German defense leaders were apparently assured that such a missile would be furnished to their Army eventually. These assurances came from the meeting that West German Defense Minister Kai-Uwe von Hassel had with Secretary of Defense Robert S. McNamara Nov. 12-14 in Washington.

Defense officials deny that an extended range *Pershing* was discussed during these meetings.

A 750-mi. *Pershing* is feasible, according to Army officials, at a cost far below development of a completely new system. The missile's inertial guidance system would have to be modified to achieve this range, but the system was designed for ranges up to 750 mi. The basic change would most likely have to be in the onboard computer.

Two methods can be used to achieve the necessary propulsion. First, and the most favored of the two, is lengthening the first-stage motor and increasing the propellant density.

The other would be the substitution of a new propellant for that now used in the *Pershing* first stage. In both instances, the second stage and the warhead—estimated at several hundred kilotons—would remain the same. Some adaption kit components would have to be replaced, officials feel.

With the demise of *MMRBM* and the increasingly effective Soviet air defenses in Western Europe, the ability of NATO forces to attack and destroy the 700-800 MRBM's and IRBM's in European Russia is being degraded. An extended range *Pershing*—capable of reaching more than 700 mi. into the Soviet heartland—would alleviate this problem somewhat. For example, it is 650 mi. from the Rhine river to Lvov, a city in the Western Ukraine, and only 450 mi. from the West German border to the Soviet Union.

Big Year Coming for Apollo

Sixteen new *Saturn* and five *Apollo* checkout stations will become operational next year, according to Maj. Gen. Samuel C. Phillips, deputy director of NASA's Office of Manned Spaceflight.

Phillips said in a speech to the National Security Industrial Assn. that 1965 will be "the year of ground testing" for the *Apollo-Saturn* system.

The 1.5-million-lb.-thrust F-1 engine will be flight rated at the Flight Research Center at Edwards AFB, and the first stage of *Saturn V* with five F-1 engines will be ground tested at Marshall Space Flight Center. The S-II stage of the *Saturn V* will be structurally tested at North American Aviation's Seal Beach Calif., facility, and S-II stage firings will be made at the Rocketdyne Santa Susana, Calif., facility.

Structural tests will be made of the S-IVB stage, and the instrument unit will enter the structural and vibration testing phase during the year at Marshall Space Flight Center. Test requirements on the Block I airframe group, which are those marked for use in the early Earth-orbital flights, will be 75% completed.

Environmental chamber testing of the Command Module also will begin at the Manned Spacecraft Center at Houston. Structural testing will begin on the Lunar Excursion Module at Grumman's Bethpage, N.Y., plant, and a LEM test article, or boilerplate model, will be mated to the *Saturn IB* for dynamic testing.

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DOD, AEC wait to see . . .

NASA Must Decide Orion Future

High-level officials argue pros and cons of nuclear pulse concept; General Atomic reports on its feasibility studies

by Willard E. Wilks

NASA WAS ROCKED by internal controversy last week as the agency tried to decide whether it should join with the Dept. of Defense and the Atomic Energy Commission in keeping Project Orion research alive for at least two more years.

The matter was variously described to MISSILES AND ROCKETS by NASA spokesmen as "a hell of a fight," a "furor" and a "battle," although some thought "fight" was a little strong.

Sources in all three agencies believe it involves broad and serious implications for both the civilian and military space programs. The Air Force particularly, along with NASA backers of the concept, believes it is vital that nuclear pulse research be carried into the next logical phase to prove feasibility following seven years of experimental and analytical effort.

However, DOD is scheduled to drop further research into the concept in January, on grounds that the Air Force cannot prove a mission requirement for such a vehicle. DOD sources believe the concept, as shown to date, is technologically sound, however, and spokesmen say the Department would be willing to contribute to a joint program to conduct the next phase of critical experiments.

To date, far more effort and funds have been poured into other nuclear propulsion concepts—concepts that Orion supporters believe show less potential or less chance of attainment.

AEC sources also say that agency would be willing to support a joint program, but "would have to be asked"—since AEC "has had the rug pulled out from under it on other nuclear propulsion programs that have shown nothing but success."

The DOD and AEC positions have hung the fate of the program on NASA as the only agency that could justify a mission requirement for a nuclear pulse vehicle.

A Pentagon source said "If NASA says 'no,' it's out."

The issue is one of the touchiest ever faced by NASA. Not the least of the considerations confronting the agency is the possibility that it could bear the onus for a decision to let the research program die, if the future—perhaps future Russian advancement—prove this to be the wrong decision.

● **The factors**—The issue contains these elements—

—A NASA official told M/R that recent studies show that nuclear pulse may be more readily attainable and have greater performance potential than other advanced nuclear propulsion systems so far considered by the agency and "probably is the only concept we have now that might permit manned missions to planets other than Mars, including a manned landing on Mercury."

—In the words of one NASA official, the organizations of Dr. George E. Mueller, associate administrator for manned space flight, and Dr. Raymond L. Bisplinghoff, associate administrator for advanced research and technology, have become "diametrically opposed" in the matter, the manned missions group strongly favoring continued nuclear pulse research.

—Serious NASA interest in the proposed Venus swingby mode for Mars missions (see p. 24) has recently affected thinking with regard to the energy requirements for manned trips. Preliminary study indicates this mode may offer the possibility of manned Mars flyby and landing missions with all-chemical *Saturn V* launch vehicles, with no need to develop a solid-core reactor system for Mars exploration. This tends to shift more attention to the higher-performance nuclear systems such as nuclear pulse, gaseous-core and nuclear-electric.

—With regard to this, as one NASA official put it, nuclear pulse appears more feasible at the moment than the gaseous-core nuclear engine approach. At the same time, while some schemes utilizing electrical propulsion may offer real advantages, the low-thrust systems cannot match the thrust levels—and shorter mission times—possible with nuclear pulse vehicles.

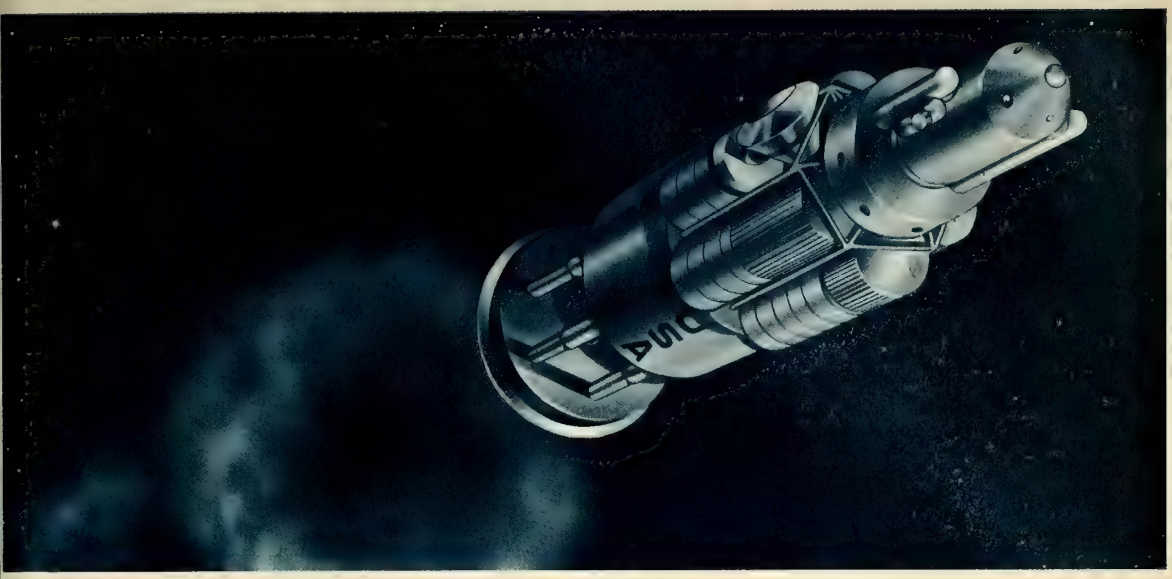
—There appears to be a growing feeling within NASA that 400 to 500-day Mars missions are too long, both from the standpoint of reliability and a space crew's mental and physical health. This is supported by reports concerning nuclear submarine crews who have been subjected to much shorter confinements without the additional disadvantage of weightlessness and other space environment problems.

—NASA and industry spokesmen favoring nuclear pulse talk of reducing manned Mars round trips to 200 days. Project Orion studies conducted by General Atomic Div. of General Dynamics show that of the nuclear propulsion concepts regarded as most feasible from a technological standpoint, only nuclear pulse can cut mission time to 200 days or less without prohibitive growth of weight in Earth orbit.

—These spokesmen also point out that the longer transit times also will mean "long mission simulations in the laboratory and in Earth orbit, thereby stretching out development time and increasing cost as well."

Both the Mueller and Bisplinghoff organizations have recently had studies conducted at the Ames Research Center and the center at Huntsville to aid NASA in reaching a decision on the nuclear pulse issue. The parallel studies examined roughly the same things—feasibility, performance potential compared with other nuclear devices, mission requirement and what sort of NASA program should be considered, if any. However, the Ames investigation was directed more toward manned missions application while the Huntsville study was broader and concerned more the overall mission potential.

● **Anti arguments**—Very strong opposition to establishment of a nuclear pulse investigation requirement for NASA is coming from one of the agency's highest-ranking officials on grounds



DRAWING of one Orion design study by General Atomic. Propulsion module, 33 ft. in diameter, would be orbited by Saturn V.

that 1) NASA has existing nuclear rocket research programs in which considerable funds are tied up and which might be compromised if something new is added, and 2) the agency has its hands full with *Apollo* and cannot afford to start any new large-scale program at this time.

Objections also are raised on technical grounds by spokesmen, such as Harold Finger of the Space Nuclear Propulsion Office, who believe the nuclear pulse concept presents very serious engineering problems that cannot be solved without an extremely expensive orbit research program. Other objections include the fact that flight tests are impossible under the existing nuclear test ban treaty, and national and international political considerations centering around the treaty and the possibility of atmospheric contamination—issues NASA would rather avoid.

• **Pro answers**—Nuclear pulse supporters charge that much opposition has been raised simply because of a near-sighted "not-invented-here" attitude by persons involved in other nuclear propulsion programs. Much of this, however, is simply due to fears of political reaction to a growing budget, other spokesmen explain.

At the same time, one top NASA source favoring support of nuclear pulse pointed out he did not favor killing off the solid-core approach, stating that nuclear pulse should be a follow-on.

Some NASA critics feel the agency is in a dilemma because a favorable reaction on nuclear pulse would call into question its past effort and funding on other nuclear propulsion programs.

A top spokesman for nuclear pulse declared that opponents in NASA are stirring up opposition by calling it a very expensive development program, whereas "actually NASA is being asked only to commit a few percent of its advanced propulsion budget over the next two years just to continue current research to a logical milestone."

Shared by three agencies, the extended program would cost relatively little for each, a Pentagon source said, adding that it would be less than what NASA is now spending on tungsten nuclear rocket research.

One bitter observation was that "you wouldn't expect this kind of furor to be raised over a piddling amount like that unless some people are afraid nuclear pulse will work, and as a result raise questions in a few years about the other nuclear rocket programs now being investigated by NASA."

• **Early backing**—Enthusiasm by some elements within NASA for the Orion concept is not new. Excitement was generated in some quarters last year following a NASA study that looked at nuclear pulse as possibly the only practical system for fast manned interplanetary missions by 1980 (M/R, Nov. 4, 1963, p. 34).

A very favorable "position report" was issued from Huntsville following the study. M/R sources reported that for political reasons even the Air Force has not yet been able to obtain a copy.

Nuclear pulse supporters complained last year they were unable to publicly defend it against some technical criticism because of security restrictions. Their cause was aided recently by a declassification enabling presentation of a stronger case for the approach while answering important objections raised against a development program.

• **Bypass treaty?**—The big point brought out in the recent report by J. C. Nance of General Atomic is that while experiments to date have been mainly on scaled samples, the research techniques utilized "appear applicable for use with up to full-scale components and modules."

In other words, nuclear pulse spokesmen say, the project can be carried "pretty close to a preliminary flight rating test without having to conduct any atmospheric tests with nuclear materials. We can carry the program up to the point where the next step would be advanced vehicle development without changing the test ban treaty, using chemical explosives above ground and underground nuclear tests.

"The techniques developed in research would permit a separable development program," a top NASA supporter said.

Underground nuclear tests would investigate dynamic response of the engine, while non-nuclear devices, including high explosives, can verify structural integrity of the propulsion system.

One Orion spokesman declared that "if we had to go into space to develop this, it would be too expensive. We couldn't do it."

Air Force spokesmen said the research program involved three basic parameters.

"These are the velocity of the propellant as it impacts the pusher plate, the temperature of interaction and the pressure. We have been able to duplicate the pressure with high explosives. We have not been able to quite duplicate the required velocities and temperatures. We have gone up to the exact

pressure, and our work says this is correct. We have gone up to a major fraction of the velocity and temperature, and our work says the data are valid. Now we need the two-year program to get the whole concept. As for temperature and velocity, there is no known way to investigate these except by underground nuclear tests to duplicate effects."

As for fears that flight tests would contaminate the atmosphere, spokesmen say "clean" nuclear explosives could be utilized or the system could be boosted out of the atmosphere with a chemical launcher.

● **Thermal control**—General Atomic reports that early calculations indicated that by reducing the engine "operating" times (or, the time during which the propellant created by each explosion interacts with the engine structure) to a millisecond, useful momentum could be transferred, although thermal waves would not have time to penetrate the engine structure.

Experiments to date confirm that common materials such as aluminum or steel can withstand surface temperatures of over 80,000°K for short time periods with only nominal ablation of the surface.

The nuclear pulse concept General Atomic has investigated amounts to an external combustion engine in which the small nuclear bombs, or pulse units, are displaced a distance from the engine structure and some fraction of the expanding explosion debris is intercepted by a flat circular structure, or piston, called the pusher plate.

By decoupling the energy source from the engine, the constraints imposed by strength of materials are relieved and considerably higher propellant temperatures and velocities can be contemplated before structure heating becomes a deterrent.

In operation, the pulse units, stored within the vehicle, are sequentially ejected and detonated external to and some distance below the engine. Momentum of the expanding debris, or propellant in the form of high-density plasma, is transferred to the pusher; resulting large accelerations are smoothed out by shock-absorbing devices to levels of a few g's in the upper vehicle.

During each interaction, the propellant creates ablating conditions in a very thin region on the bottom surface of the pusher. A great deal of effort has been directed toward understanding the mechanics of ablation, how it varies with propellant conditions and pusher materials, and predicting quantitatively what its effect will be for realistic designs. Performance is influenced by the amount of mass lost by the ablation process, and it represents a key problem area. Thermal conditions are constrained to the pusher surface and little bulk heating of the plate itself will accrue.

An important point that is frequently misunderstood, Nance reports, is that for propulsive purposes "we are ultimately interested in total momentum imparted to a vehicle with as little internal energy increase as possible. In the case of Orion the internal (heat) energy transfer to the pusher is only a very small fraction of the total energy available. This very important characteristic permits maintaining the major engine components at operating temperatures low enough so that common construction materials such as steel, titanium, organic fibers, and elastomers may be used."

● **Low radiation**—Because of remoteness of the energy source from the engine, nuclear radiation levels in the structure are low enough so nuclear heating effects are relatively unimportant.

Investigators say that radiation levels remain so low that crewmen could "walk on the pusher plate an hour or so after engine shutdown."

Results of reference design studies include a propulsion module of about 200,000 lbs. gross weight and 33 ft. in diameter. Thrust-to-weight ratios of such modules would be somewhere between one and six. Predicted specific impulse is calculated to be 1,800-2,500 sec., resulting in characteristic single-stage velocities of about 100,000 fps.

The module depicted was selected for compatible lofting to orbit by a two-stage *Saturn V* vehicle.

Vehicles utilizing such an engine from Earth orbit could typically deliver 45% of their gross weight as useful payload to the lunar surface, over 40% to the Mars surface, and could carry in excess of 25% on a fast, manned round trip to Mars with landing. ■

DCA Seeking Ideas for Improved Comsat

THE DEFENSE Communications Agency plans to ask industry for its ideas on the advanced defense communication satellite system which is expected to replace the interim system now under development. Requests for proposals are to be issued Dec. 14 to qualified firms, with a bidder's conference to be held Jan. 19.

DCA will ask the firms selected to "define the system approach and development plan" for the advanced military comsat. A series of such studies will be conducted by industry in a "brain-picking" operation to determine concepts "on the optimum communications satellite system choices to meet national communications needs."

Following the bidder's conference, the solicited firms will be required to submit proposals for the study by Feb. 24. Contract awards are expected to be made by approximately next April 15.

● **To be asked**—Firms DCA intends to solicit include: Bendix Radio Div., Bendix Corp.; Boeing Co.; ComSat Corp.; General Dynamics Corp.; General Electric Co.; Hughes Aircraft Co.; International Business Machines Corp.; Ling-Temco-Vought, Inc.; Lockheed Aircraft Corp.; Martin Co.

Also, Philco Corp., a subsidiary of the Ford Motor Co.; Radio Corporation of America; TRW Space Technology Laboratories; Sylvania Electric Products Inc.; Western Electric Co. and Westinghouse Electric Corp.

Other companies that feel they are qualified to do the work but are not listed above can submit a summary of their qualifications before Dec. 31, according to DCA. Such submissions will be considered for addition to the bidder's conference list.

● **Study scope**—Contractors selected for the study will conduct an analysis of requirements, system synthesis, system analysis, evaluation and program planning that is to result in a system definition study. DCA expects to be able by this method to present DOD with an itemized list of technical concepts within industry and in sufficient detail to enable final system definition.

The 40 man-month study efforts will cover such technical areas as: communications requirements analysis, communications system technology, orbital configuration design, satellite and dispenser design, surface station design, launch vehicle performance, vulnerability analyses, system deployment and replenishment strategies, system control, network planning, and cost effectiveness evaluation.

The study results will be submitted within 90 days after contract awards. This scheduling would enable DCA and the Defense Department to initiate development in Fiscal 1966 or at least to go into program definition for the system. ■

Dec. 18 launch planned . . .

Satellite Readied To Probe Radiation Belt Energetic Particles

LATEST IN A SERIES of *Explorer* satellites to investigate the still-not-completely understood phenomena by which energetic particles are injected, trapped and eventually lost in the Earth's radiation belts is scheduled for launch Dec. 18 from Cape Kennedy.

The 101-lb. radiation detection satellite will carry an improved telemetry system that will operate continuously to allow real-time data acquisition by tracking stations. In addition, many of the electronic components have been made more radiation resistant than the previous satellites in this category, such as *Explorer XV*.

The satellite will be launched into a highly elliptical orbit of 15,800 mi. apogee, 200 mi. perigee on a three-stage *Delta* rocket. Orbital period will be slightly more than seven hours at a 21 degree inclination to the equator to keep it near the Earth's geomagnetic equator.

The *Energetic Particles Explorer D (EPE-D)*, formerly called S-3c, was designed and built by Goddard Space Flight Center. Electro-Mechanical Research, Inc., provided electrical integration. Although it has a design lifetime of one year, officials say they will get useful information if the satellite remains operating for three months.

● **Experiments detailed**—Five experiments will be carried by the octagonal satellite, which is 17 in. high and 27 in. dia. The main body is of glass fiber honeycomb construction, with a thin aluminum cover. Four solar panels protrude from the sides, and a 34-in. magnesium tube extends from the center for one of the experiments.

Experiments to be carried on-board:

—*Electron-proton angular distribution and energy spectra*—a series of solid-state detectors to measure the spatial and angular distribution and energy spectra of electrons and protons. The experiment was designed by Dr. Walter L. Brown, Bell Telephone Labs.

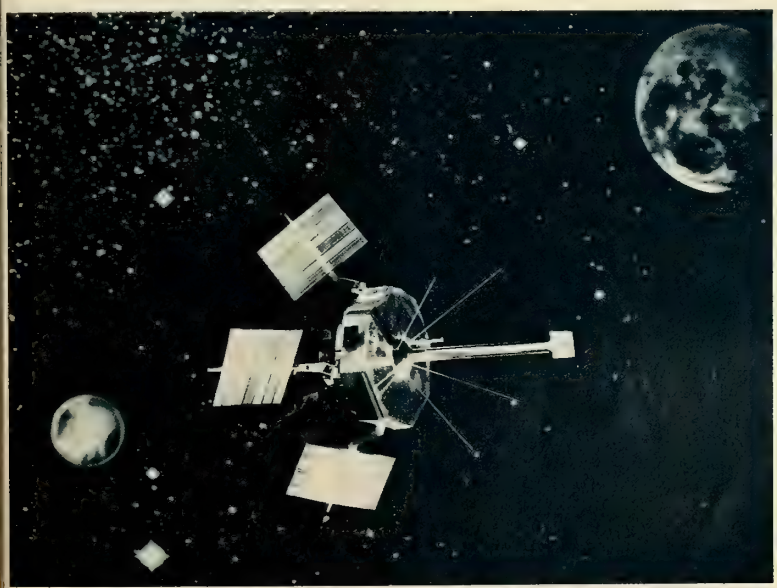
—*Electron-proton directional-omni directional detectors—scintillator*-type detectors originally developed for use on the *Relay* communications satellite. They are to measure the intensity and angular distribution of protons and electrons. Experimenter is Dr. Carl E. McIlwain of the University of California, San Diego.

—*Flux-gate magnetometer*—This instrument mounted on the central boom will measure the magnitude and direction of the Earth's magnetic field from 6,000 mi. above the Earth to apogee. Data on electron and proton experiments will be correlated with these measurements. Dr. Laurence Cahill of the University of New Hampshire provided this experiment.

—*Ion-electron detector—scintillator* detector designed to measure relatively low-energy particles by type and energy as a function of direction, time and position. Leo R. Davis and James M. Williamson of NASA's Goddard Space Flight Center designed this experiment.

—*Solar cell damage*—to provide means of determining damage to a group of solar cells by Van Allen radiation and starfish radiation caused by the U.S. nuclear explosion of July 9, 1962. It includes four groups of 10 "n on p" silicon solar cells with different base-resistivities and cover shield thicknesses which are mounted on the side of the main body of the satellite. Luther W. Slifer, Jr. of Goddard is the experimenter.

The satellite will be commanded by Bell Telephone Laboratory radio-guidance system for trajectory corrections during the first- and second-stage powered flight. After the command occurs for second stage cutoff, a four-minute coast period occurs. During this time, the satellite and the third stage are spun up by small rockets mounted between the second and third stages. The third stage then separates and ignites, putting the satellite into orbit. Spin rate in orbit is about 25 rpm. ■



DRAWING of 101-lb. Energetic Particles Explorer D (EPE-D) satellite in Earth orbit.

Soviets May Not Have Extravehicular Space Experimentation Capability

Sea-level-pressure helium-oxygen could result in cosmonaut decompression sickness in switch to lower-pressure spacesuit

by Heather M. David

SOVIET INTEREST in the use of helium-oxygen atmospheres for long-term space vehicles may indicate that they do not have capability for extravehicular experimentation, says Dr. Eugene Konecci of the National Aeronautics and Space Council.

The U.S. chose several years ago to go the 100% oxygen route for its *Mercury, Gemini* and *Apollo* vehicles. This makes it possible to carry out extravehicular operations, in which the astronaut must go to a slightly reduced pressure for spacesuit operation, without fear of bends. However, since the Soviets have developed a two-gas capsule atmosphere of oxygen and nitrogen at sea-level pressures, they are faced with a very grave possibility of decompression sickness if the cosmonauts must go to a spacesuit pressure low enough to permit performance of useful tasks.

The Soviet spacesuit is believed to have pressure of 7.5 psi, with air for the body pressure and pure oxygen in the helmet. However, to reduce the pressure to 5 psi, so that the suit does not have balloon-like rigidity, a period of denitrogenation would be necessary. If, as is believed, the suit has an oxygen supply of only one hour, it is strictly an emergency-type garment.

Konecci, chairman of the bioastronautics committee of the International Astronautical Federation, pointed out to M/R that there has been no mention of airlocks in public or private descriptions of the *Vostok* and *Voskhod* vehicles, and no other indications of plans for extravehicular operations. While the Soviets are aiming at rendezvous, this is expected to be strictly a vehicle maneuver.

It is this kind of decision which is plaguing Air Force bioastronautics experts in their choice of the atmosphere for the *Manned Orbiting Laboratory* mission (M/R, Dec. 7, p. 22).

The Soviets have carried out a program of helium exposures, both with animals and humans (M/R, Nov. 23, p. 14), and have verbally referred to exposures of 120 days. The U.S. Air Force School of Aerospace Medicine has just concluded a month-long simulation of a 44% oxygen, 56% helium atmosphere at 18,000-ft. altitude. Although one of the four subjects had to be removed from the chamber and hospitalized for tests for a liver inflamation, there were no apparent changes due to the atmosphere itself. The inflamation was discovered in blood samples during the sea-level control period.

However, no decompression tests have yet been run with subjects who have been breathing the helium-oxygen mixture. While it is believed that no bends will result because helium is not absorbed in body fluids, there is no real proof that some difficulties may not occur.

Konecci, formerly chief of biotechnology and human research at NASA's Office of Advanced Research and Technology, said that the Soviets have shown considerable interest in the *Gemini* extravehicular operation experiment plans, and will take a "wait and see" attitude for this data. The Soviets have revealed that they have looked at the 100% oxygen environment, having exposed animals for 98 days with no ill effects at 200 mm Hg.

● **Fear of spaceflight**—There has been much mention in the press that the Soviets are greatly afraid of prolonged spaceflight because of changes which might occur in the cosmonauts' systems. Some sources have even concluded that the 24-hour *Voskhod* flight was limited to this time because the Soviets feel that this is the longest safe period of weightlessness—the time before irreversible changes which lead to death take place. However, other officials have pointed out, this is largely a matter of conjecture, since the *Voskhod* time period is a logical engineering step in the development of a new spacecraft.

The Soviets, like U.S. physicians, have been especially concerned about the effect upon the cardiovascular system. With the experience of longer periods of weightlessness—up to the five-day flight of Byovsky—they have concluded that this effect is of a phasic character related to the period of flight (M/R, Oct. 21, 1963, p. 34).

● **Their instruments**—According to a book published in the Soviet Union last year, a new method of dynamocardiography was developed and has considerable spacecraft application. This instrument measures the physical or mechanical processes associated with heart contraction and the displacement of the center of gravity of the thorax in relationship to a specific support, such as a table or possibly a cosmonaut's couch.

Through the device, which measures 30 x 30 cm and is 5-10-mm thick and is supported by elastic elements, the forces acting from the thorax of the subject which "deform" the elastic elements are translated into electrical signals. With this tool, mechanical manifestations of cardiac activity not available through electrocardiograms, blood pressure and other methods could be obtained.

Soviet sources report that this instrument, which can be used as a flat case or portable device that can be placed directly under the subject's thorax, is now being mass-produced in the Soviet Union.

They say they divide their bioinstrumentation into two "blocks." The medi-

cal control block includes instruments for electrocardiography (EKG), measurement of chest perimeter (CP) and motor activity (MA) and thermometry (M). The second block, presumably the non-continuous measurements, are those concerned with medical investigations. They include electric activity of the brain (EEG), electric activity of the eyes, cutaneogalvanic reaction (CGR), maximum and minimum arterial pressure, muscular fatigability, impairment of coordination of movements, and other special tests.

One of the experiments involved writing with an actograph, in which the subjects tried to reproduce a previously memorized assigned set of symbols or letters. These were performed on a small platform with electrical pickups which signaled changes in the speed with which the pencil moved vertically and horizontally. Impairment of fine coordination was extrapolated from the differences in first and second versions of this test during the flight. Changes occur during the early phases of the flight, the Soviets say, with a stabilization after a sleep period.

● **Ground tests**—The Soviets also appear to be carrying out an extremely ambitious program of ground simulations, which have lasted from 10 to 120 days. These tests apparently have been aimed at atmosphere and microflora investigations, with other effects simulated. These included small doses of ionizing radiation, periodic rises in temperature, noise and other environmental changes.

One of the unexpected results was the discovery that the cabin air, in the absence of any equipment which produced carbon monoxide, still contained this gas. The source was found to be the men, who produced CO as a result of biochemical conversions which the Russians said have been insufficiently studied. This concentration of carbon monoxide caused autointoxication, which was detected by definite changes in the central nervous system and by analysis of the blood.

Bacterial count also increased considerably with time, and the concentration on the men's skins became more and more dense as the bactericidal property of the skin was lost. U.S. scientists have found that in similar experiments there is a leveling-off period as the natural balance is established among the occupants of a sealed chamber and the equipment.

The Russians also divided the ground tests into a series of phases. In the first phase, from 10 to 15 days, measurements of the circulation regulating system indicated that "a certain inertness" developed. The same kind of reaction was apparent in the gas interchange system, where the efficiency of its work was considerably decreased. An inhibiting process was also observed in the central nervous system and adrenal cortex.

Next phase is an adaption period, with a normalization of functions. However, the Soviets said they noticed an increased fatigability. The Soviets used the term "asthenization," to describe the total condition of reduced working capacity, enhanced fatigability, change in the sleep function, weakening of immunal reactivity, reduction in the functioning of the cariovascular system, decrease in efficiency of physical work and changes in the nervous processes.

After 60 days, they said, the subjects emerged with another reaction. In this, the asthenization actually deepened for a period. This state lasted about two months. The Soviets then conducted tests lasting 120 days, in which they applied additional means of purifying the air to remove bacteria and contaminants, ultraviolet irradiation of the subjects' skin, increased vitamin intake and special physical exercises and drugs. This, coupled with a more gradual transition from ordinary life conditions, considerably decreased the intensity and duration of the reaction, the Soviets said.

● **Accelerations**—The Soviets seem to have less hesitancy about using drugs for various purposes in decreasing stresses in spaceflight than do U.S. doctors, who are reluctant to use them since drugs used for one-purpose usually will have effects on other aspects.

Soviets have used white mice, rats, rabbits and dogs, in tests in which they administered strychnine, epinephrine, norepinephrine, benzadrine, phenatine, caffeine, cardiazol, chloral hydrate, and sodium pentathol.

Best results, they say, have been with strychnine, some sympathomimetics, and anesthetics. White mice injected five times with small doses of strychnine were able to tolerate 6.6 g's more than those in the control group, and mice exposed to 6.6 g's had a survival rate of 21% higher than controls. Dogs and rabbits also suffered less severe effects on the functions of their hearts when injected with strychnine. Varying doses of the other drugs also produced beneficial effects.

The Russians said that care must be used in administering these drugs, however, because the degree of sensitivity of the animals changes with exposure to flight and new environmental factors.

In particular, they said, ionizing radiations and accelerations may produce changes in the animal's bodies which turn a formerly beneficial drug into a poison.

In studying the effects of accelerations on humans (the Soviets said that they have completed about 500 experiments using about 70 subjects), the scientists disclosed that they found that optimum conditions were created when the angle between the total acceleration vector and longitudinal body axis approached 80°.

At a 12-g acceleration, they said, the 80° angle offers two to three times more endurance than does a 65° angle. Pure oxygen "considerably improved the morale of the subjects," a report by Soviet scientists A. S. Barer said.

Subjects were monitored for EKG, arterial pressure, volume indices of external respiration, electromyograph, electroencephalograph, acuity and field of vision. In some experiments, X-rays were taken of the chest organs and a gas analysis performed on exhaled air.

● **Space tools**—Material translated by Electro-Optical Systems, Inc., reports on Soviet development of three tools which could be used in weightlessness to repair space vehicles.

The first is a combination flat-nosed plier and wrench with two spring-connected handles for tightening or loosening bolts. The second, which Russian sources imply is for use on liquid-propellant systems with their many fittings, is a combination of two wrenches. This is arranged so that the torque applied to the first handle is counteracted by using the second as an anchor.

Third is an electrical, battery-operated device in which torque is eliminated by a counter-rotating shaft housing. This tool apparently operates on the same principle as one developed by the Martin Co. and Black and Decker Tools for the Air Force. ■

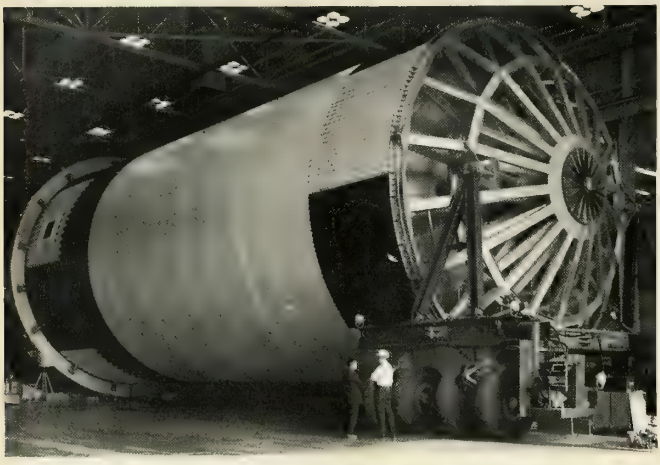
NASA Readying Advanced Life-Support System RFP's

NASA's Office of Biotechnology and Human Research in the Advanced Research and Technology Division is reportedly preparing two new requests for proposals for development of advanced life support systems.

The first is to be an "intermediate" system, which would support a multimanned crew from six months to a year. The second, which would be procured through Ames Research Center, would be a long-term system capable of sustained operation from one to three years.

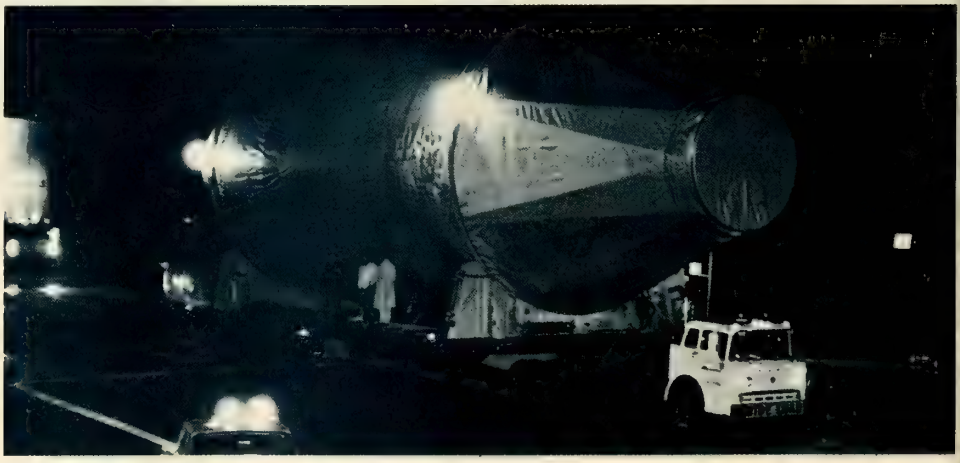
If the contracts follow the pattern usually followed by this office, the equipment to be designed will be flight-prototype. NASA now has developed a six-month system, which calls for 90-day resupply of some components. This was developed under a contract to General Dynamics/Astronautics.





The News in Pictures

ABOVE: Air Force/Lockheed SR-71 strategic reconnaissance aircraft is publicly shown for first time at Edwards AFB, Calif. Plane will be assigned to SAC's Beale AFB, Calif., next year. LEFT: NASA/-Marshall Space Flight Center Saturn V static test booster (S-IC-T) being assembled at Marshall. Shown here is forward end of 33-ft.-dia. booster, including forward skirt, liquid oxygen tank and intertank section. BELOW: Douglas Saturn S-IVB upper stage enroute to Seal Beach, Calif., where it began three-week, 6,000-mi. trip by barge and freighter to MSFC, Huntsville, Ala. BOTTOM: Scientists inspect Apollo boilerplate Command Module after "letter perfect" Dec. 8 flight test (see cover) simulating catastrophic launch vehicle failure under maximum aerodynamic pressure to test Apollo launch escape system.





Technical Countdown

ASTRONAUTICS

Soviet Style SNAP 10A Developed

The USSR has developed a nuclear reactor for space applications. The unit, according to an Electro-Optical Systems, Inc., translation of an article in the September technical supplement of *Pravda,* weighs an estimated 500 lbs. with an output of 500 watts, 88 amps, through direct control of reactor heat with beryllium reflectors. Silicon-germanium thermoelectric elements are located on the exterior side of the reflectors for cooling and on the interior side for active zone heating to a temperature of 1,770°C. Nicknamed "Romashka" (Daisy), it uses enriched U-235. The Russians claim to have run it continuously 400 hours without failure. The Daisy is comparable in power levels to the U.S. SNAP 10A power source, but since the SNAP unit has heavy shielding instead of reflectors and uses a NaK loop, its weight is about 950 lbs. The SNAP approach is believed to be more feasible for higher power output than the reflector method.

SPACE MEDICINE

Apollo Earth-Orbit Space Suits Under Contract

The David Clark Co. of Worcester, Mass., will submit a cost proposal for an *Apollo* early Earth-orbital space suit assembly based on the *Gemini* design. NASA's Manned Spacecraft Center requested the proposal from Clark. The firm has a contract for the *Gemini* suits and the add-on will involve a modified *Gemini* suit incorporating anticipated minor changes. A separate contract will be negotiated at a later date for the *Apollo* early orbit suit as part of the current *Gemini* contract with the company.

Hi-Speed Low-Altitude Tests Planned

A new four-degree-of-freedom g-seat is being checked out at North American Aviation's Columbus Div. simulation laboratory. The seat moves 20 ft. in vertical translation, four feet in lateral translation, 30 degrees in pitch, and 90 degrees in roll. The device will be used to study the problems of low-altitude, high-speed flight. A dummy will be used in some of the tests.

Simulated MOL Tests Slated

The Air Force School of Aerospace Medicine will conduct a series of experiments with volunteer airmen living on an experimental liquid diet while confined in a space cabin simulator for 30 days. Altitude will be 19,000 feet, with atmosphere 50/50 oxygen/nitrogen. In each test, food and water requirements, respiratory gas exchange, gastrointestinal function, microbiological factors, dental health, and psychological factors as they contribute to the nutritional health of the subjects will be monitored. The tests are aimed at requirements of the *Manned Orbiting Laboratory.*

ELECTRONICS

AROD System Funded

Motorola's Western Military Electronics Div. was awarded a $2-million R&D contract Dec. 8 by NASA's Marshall Space Flight Center to develop the Airborne Ranging Orbital Determination (AROD) system. Under the 15-month program, the Scottsdale, Ariz., division will design and build a flight tracking system for use with ground radar beacons, thus reversing the usual roles of ground and flight systems in the tracking operations. The flight hardware, using integrated circuits and other microminiaturized subsystems wherever possible, will employ a CW, S-band radar to provide either launch vehicles or spacecraft with position and velocity data. For each interrogation, three ground beacons will be required for the trilateration measurement approach. Navigational inputs thus derived in the space vehicle in near-real-time will be fed directly to the craft's guidance system or displayed.

Seeing High-Temperature Crystal Growth

Difficulty of microscopic study of semiconductor or laser crystal growth because of high temperatures and excessive self-radiation is overcome in a furnace developed by Astro Research Corp., Santa Barbara, Calif. Crystal is illuminated by ultraviolet light and viewed through an image converter. Infrared and visible radiation is screened off.

PROPULSION

Valveless Rocket Under Contract

Rocket Research Corp. will develop its valveless rocket (M/R, Sept. 28, p. 18) for the *Applications Technology Satellite* Program under a $1,312,063 cost-plus-incentive-fee contract with Hughes Aircraft Co. Two types of control device will be built—one having a thrust level of 10^{-5} lb. and the other 10^{-4} lb. The motors will handle station keeping and other corrections for gravity gradient stabilized satellites at stationary altitudes and also at medium altitudes under the program. The valveless rocket uses on-board electrical energy to sublimate a solid propellant.

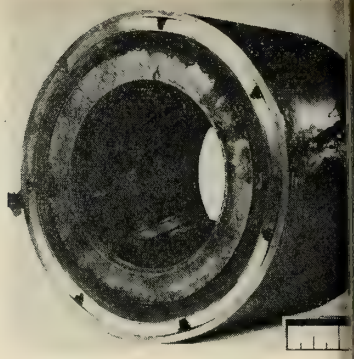
UTC To Look at Large Rocket TVC

United Technology Center will examine the use of its *Titan III-C* thrust-vector-control system on larger rockets under a 90-day study contract from NASA. The specific propulsion system involved is a half-length, 260-in.-dia. solid rocket currently in development for NASA. The 120-in TVC system for the *Titan III-C* has demonstrated a side force of more than 100,000 lbs. In operation, the steering force is achieved by injecting nitrogen tetroxide into the nozzle.

MATERIALS

Uniform Carbon Laminated Panels Developed

Carbon cloth laminated panels up to 4 in. thick and using a phenolic resin are said to be 100% uniform in structure by their developers, the Aerospace Div. of Haveg Corp. The liminated cloth panels are cured at 1,000 psi in a newly built, electronically instrumented hydroclave. Haveg Aerospace claims to have eliminated the delamination problem through a technique of molding with controlled, uniform heat during the critical phase of the curing cycle. The electronic controls assure uniformity over long production runs.



OPPOSITE PAGE: Combustion chamber pressure test trace of above nozzle in 85-sec. firing at 1,500 lbs. thrust. Slight drop is caused by nozzle expansion—not erosion.

Non-Eroding Nozzle Under Development

Curtiss-Wright's graphite wedge unit is particularly suited for applications calling for high-energy propellants

by John F. Judge

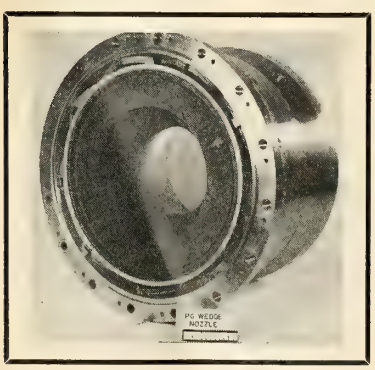
WOOD-RIDGE, N.J.—A pyrolitic graphite wedge-nozzle concept is being developed by the Wright Aeronautical Div. of Curtiss-Wright Corp. for current and future high-performance rocket engines.

The nozzles are particularly suited for advanced propulsion systems demanding long continuous and intermittent firings with high-energy propellants. The Wright nozzle works better with fluorine than with conventional Earth-storable propellants.

The wedge nozzle consists of tapered pyrolitic graphite plates stacked circumferentially around the longtitudinal axis. The number of these wedges required for a given nozzle assembly is determined by the ratio of the outside diameter to the inside diameter of the wedges, and the thickness of the pyrolitic graphite plate available. Initial firing tests reveal no detectable erosion.

● **Long history in graphite**—The wedge concept evolved from several years of working with pyrolitic graphite.

THIS WEDGE NOZZLE/nested leaf spring design was used in a recent F_2 firing.



George S. Kelley, manager, missile and space propulsion department at the Wright Aeronautical Div. calls the material a prime contender for these engines because of its high-temperature strength and anisotropic nature (conductive in one direction and insulative in the perpendicular direction).

Early work at the Division resulted in a wafer design approach to pyrolitic graphite heat sink nozzles. In this concept, the graphite plates are stacked perpendicular to the nozzle centerline. A second innovation included tapered wafers.

Test firings were initiated in July, 1961, with the wafer concept. Subsequent firings and analyses pointed out several inherent limitations.

There were problems in high thermal axial expansion and a limited heat-sink ability. There was also a re-start limitation. In the wafer design, heat flows radially outward along the conducting planes of the pyrolitic graphite, and since the plates act as insulators in the axial direction, essentially all the high heat input at the nozzle throat must be absorbed by the wafers at the throat.

The only route to increasing the heat capacity of the design is to increase the diameter of the nozzle insert section.

● **Thermal escape paths**—In the wedge concept, the heat flows from the throat area to the cooler portions of the nozzle assembly because the pyrolitic graphite planes of high thermal conductivity are located in the radial and axial direction.

Wright designers can restrict the amount of heat entering the convergent and divergent portions of the nozzle, making more heat-sink volume available for the throat section. This is achieved through a choked wedge design where the restriction can be as simple as machining a gap in the wedge.

The result is a throat running cooler for a longer period of time.

Kelley says the thermal criterion in designing such nozzles is not the melting point of the graphite but what he defines as "the threshold of erosion." This is based on the chemical reactions of liquid-engine exhaust products with the pyrolitic graphite.

These chemical reaction rates are exponential with temperature and a well-defined temperature band exists where reaction rates are high enough to produce a measurable erosion rate.

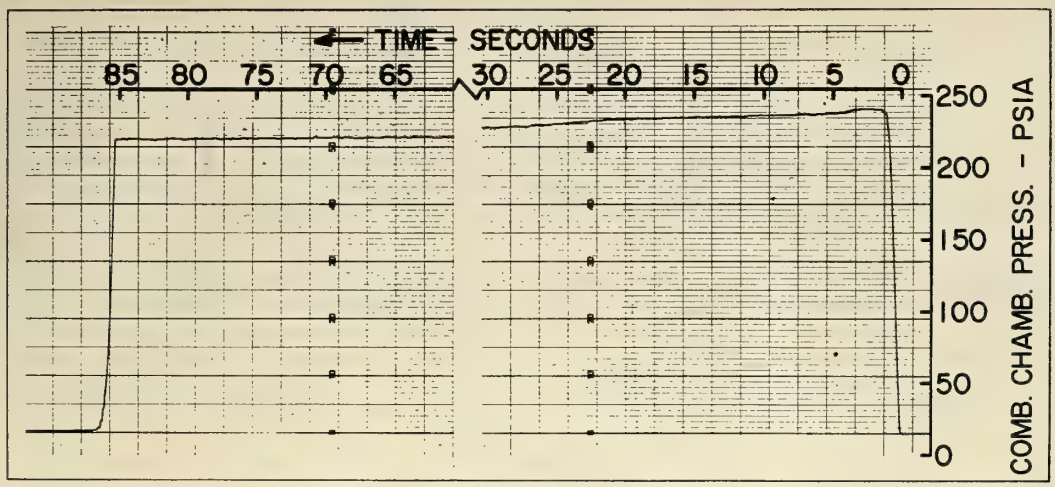
For example, the threshold of erosion is between 3,500° and 3,800°F with N_2O_4/UDMH-N_2H_4 and indications are that it rises to the 4,200° to 4,500°F area in fluorine propellants.

In comparing the various pyrolitic heat-sink designs, the significant parameter as defined by Kelley is the firing time to reach this plateau. The wafer, wedge and choked wedge concepts are 90, 183 and 305 seconds, respectively, in comparison tests—with all conditions identical.

● **Early problems**—Early efforts with wedges proved to be fairly difficult because of the anisotropic expansion characteristics of the configuration. The high axial expansion meant the restricting bands had to be designed to accommodate this growth. Otherwise, the stresses introduced led to nozzle failure.

Kelley and his group solved this initially by restricting the wedges through a leaf-spring arrangement. This design has now been changed to what is called a watchband sleeve. This is a solid metal band with machined holes, which acts like a spring.

The wedges themselves meet at the



throat section on machined lands. This again helps to overcome the differential expansion properties of the graphite in the nozzle configurations. The gaps behind the lands may have future applications in gas-cooled nozzle designs.

Each wedge is fabricated from pyrolitic graphite slabs to precise specifications. A number of tests are performed on material cut from each wedge-slab, and a complete quality check is thus built along with the nozzle.

Final machining is performed on the assembled nozzle and the final checks are largely dimensional.

● **Limitless life**—In all the firings to date, there has been no detectable erosion, even though the nozzle is formed from discrete sections with interfaces in the critical throat area.

The spring action of the watch band provides an initial pre-load on the lands of the wedges in the nozzle. It maintains this during the firing. The initial pre-load is set so that gas pressure will not result in gaps between the wedge land surfaces.

Curtiss-Wright has conducted well over 200 hot firing tests on pyrolitic graphite nozzle designs over the past 3½ years. The thrust levels ranged from 50 to 5,000 lbs. with chamber pressures from 50 to 1,200 psia.

Wedge nozzle designs have not shown any evidence of erosion after as many as nine engine re-starts. The many tests have also been in complete agreement with theoretical results from three-dimensional thermal and anisotropic structural analyses.

The latest test—involving fluorine—was part of a contract with the Air Force propulsion labs at Edwards Air Force Base. The results are classified, but the general indications are that the test was extremely successful.

● **Funding**—The graphite work at Curtiss-Wright has been largely a company funded effort, with some Air Force support. Patents are now being issued for some of the wafer designs.

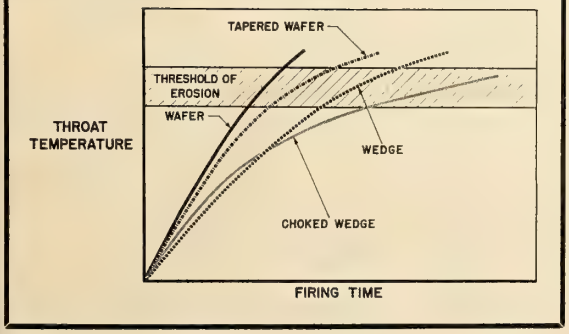
The nozzle work under Kelley is coupled to an engine design ability. The optimum operation of a nozzle in any given application is not only a function of nozzle design but depends on engine characteristics such as injection modes, propellant mixing, combustion and other system parameters.

Kelley's group has engine designs based on the pyrolitic graphite concepts and a swirl-cup injection scheme. The technology involved is being applied to NASA's *Saturn* common engine proposal request.

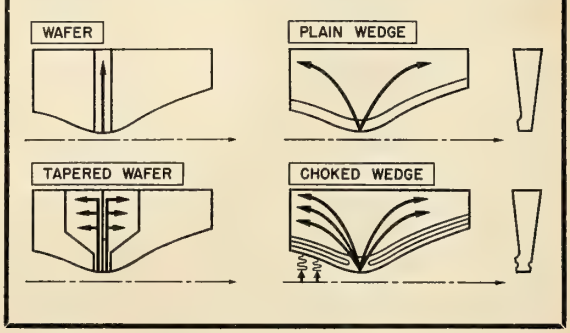
● **Thrust range**—The propulsion area covered by the development includes thrust levels from 50 lbs. to 5,000 lbs. and beyond—using high-energy liquid propellants. The pyrolitic nozzle is ideal for high-energy solid propellant applications. In fact, this is where Curtiss-Wright initially started its development effort.

The back-up insulation in the current nozzle configurations is usually a standard grade of conventional graphite. Kelley says some work has been done in pyrolitic graphite combustion chambers, but the general feeling is that plastics can do the job as well. ■

NOZZLE DESIGN comparisons with all conditions identical.



NOZZLE concepts with conducting direction indicated.



Venus Swingby Would Permit Using Saturn Hardware on Manned Mars Trip

STL study for NASA also recommends use of aerodynamic breaking at both Mars and Earth; SISD investigates use of Apollo hardware

by Willard E. Wilks

STUDIES UNDER WAY for NASA suggest that manned flyby and landing missions to Mars could be a direct follow-on to the *Apollo* program, utilizing an *Apollo* Earth-entry system and *Saturn V* launchers.

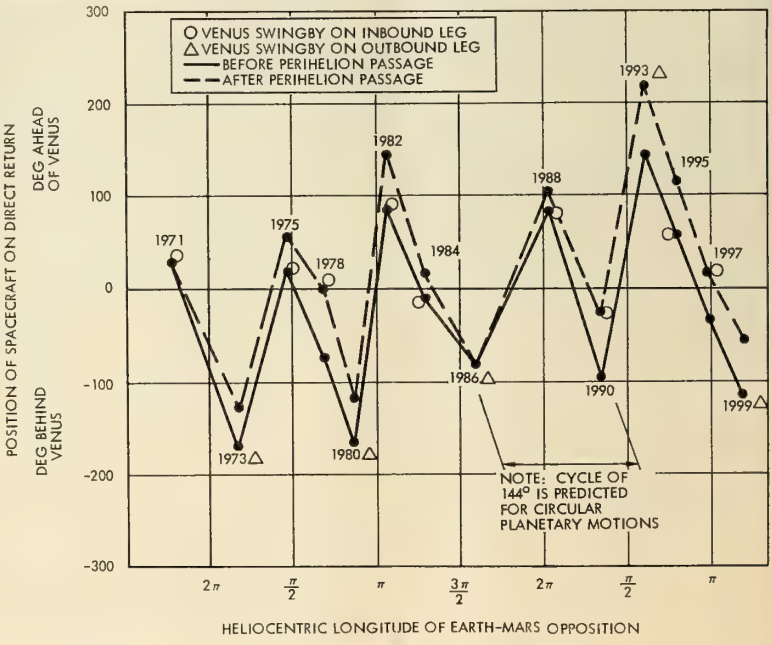
Feasibility investigations give emphasis to using *Apollo* equipments in the flyby mission wherever possible.

Industry sources believe weight and propulsion requirements of the Mars mission could be cut down to *Apollo* size and technology by two means:

—Use of the gravitational field of Venus to decelerate the spacecraft on the return trip, greatly reducing Earth-entry velocities to a range of 40,000 to 50,000 fps, compared with 46,000 to nearly 70,000 fps for the direct Earth-Venus mode.

—Use of aerodynamic braking at both Mars and Earth. It is believed Earth-entry velocities resulting from the Venus swingby could be handled with aerodynamic braking, in some cases by *Apollo*-type entry design. Further investigation is recommended into the problem of entry at higher velocities up to 70,000 fps to establish feasibility and set practical upper limits on Earth-entry velocities.

Studies report that by utilizing these means a manned Mars landing mission could be accomplished with four to six launches of conventional *Saturn V* vehicles, or three to four launches of an uprated *Saturn V*.



HELIOCENTRIC positions of Mars spacecraft with respect to Venus during inbound passages. Proposed Venus return mode is achievable in 9 of 14 opportunities.

● **New thinking**—One industry source described the approach as a "breakthrough in thinking over older approaches which used retro-braking almost exclusively. This resulted in size becoming very big, and it got into the region where nuclear systems were very attractive, if not mandatory. Now we get back to where we can use conventional propellants again, and to a size where *Saturn* boosters and a modified *Apollo* Command Module could be used."

North American Aviation's Space & Information Systems Div. has been investigating use of existing *Apollo* hardware for a manned Mars flyby mission, and TRW Space Technology Laboratories has recommended the Venus swingby mode and aerodynamic entry in a study performed for NASA's Ames Research Center.

The STL investigation considered a number of round-trip missions ranging to 500 days, with time spent around and on Mars varying between 10 and 60 days.

The study assumed a Mars atmosphere density of 2% of Earth's, based on current models, with entry velocities of 25,000 to 30,000 fps encountered. For Mars entry, a relatively pointed body probably would be necessary because of the presence of CO_2 in the atmosphere, giving rise to strong radiation heating over blunt shapes.

According to the STL investigation, use of aerodynamic rather than propulsion braking at Mars would reduce

TECHNICAL HIGHLIGHTS FROM A RECORD YEAR OF RESEARCH

In the past fiscal year, Cornell Aeronautical Laboratory carried out contracted and internally sponsored research of a record volume—some $19 million. A report covering some of this research and its accompanying advances in technology has just been issued. Here are some of that report's technical highlights.

- In aerodynamics, we ranged from the low-speed to the hypersonic regime: One program has been aimed at an improved method of predicting the performance of propellers on tilt-wing VTOL aircraft, another is leading to a better understanding of communications blackout experienced by space vehicles entering the earth's atmosphere.
- In aircraft dynamics, CAL's research and testing with variable stability aircraft took on new impetus: Using the variable stability, variable drag T-33, longitudinal flying qualities in the landing approach condition were investigated for the first time by in-flight simulation techniques. Research began on the Bell X-22A VTOL which will give it a unique capability for in-flight simulation over its entire flight regime, including transition.
- In atmospheric physics: A model of the structural properties of warm fog was constructed and a method of controlling the growth of individual fog droplets devised. Echoes from the aurora were detected with CAL's High Power radar at the unusually high frequency of 2850 megacycles.
- In computer sciences: Pattern recognition techniques have resulted in 77% accuracy in predicting solar flare — a serious threat to astronauts — with significant improvements anticipated. A new high of 95% recognition performance by a perceptron in aerial photo-interpretation of noisy target silhouettes was scored. A special purpose computer which automatically detects and locates targets to the limits of information available from the search radar was designed and delivered to the Navy for shipboard evaluation.
- In electronics: A low-level, terrain following subsystem of the Integrated Helicopter Avionics System was designed and evaluated. The design of antennas for a thermal environment of 2000°F was investigated. Dence electron and ion emissions were obtained from a laser-illuminated cathode with important applications in electric propulsion, surface technology and electronics.
- In experimental facilities: A new 96-inch high energy shock tunnel became operational, providing a Mach 5-30 velocity range with stagnation temperatures reaching 8000°K. The long-duration Wave Superheater hypersonic tunnel showed increased usage with emphasis on material ablation investigations in a high-shear, high heat flux environment; rotor discharge conditions in the Superheater reached as high as 7200°R and 110 atmospheres.
- In radar signature technology: For missile defense, we changed emphasis from discrimination techniques effective before re-entry to those during re-entry; progress was made in the attendant problems of data processing and computer techniques to effect recognition. To improve survivability of tactical aircraft, techniques were evolved for reducing the radar cross section of Army and Air Force aircraft.
- In reconnaissance: The application of spectral photographic techniques to counter insurgency environment was evaluated and an investigation made of optical and digital techniques for target enhancement as pre-processing for automatic recognition.
- In systems research: CAL's long-standing efforts to enhance AICBM terminal defense were complemented by research to determine the amount of satellite shape information that can be obtained with a ground based multistatic radar array. Evaluation began of the effectiveness between various penetration aids for modern Air Force tactical fighters. The characteristics of Army air traffic in the battlefield area underwent investigation to determine the critical problems of air traffic regulation.



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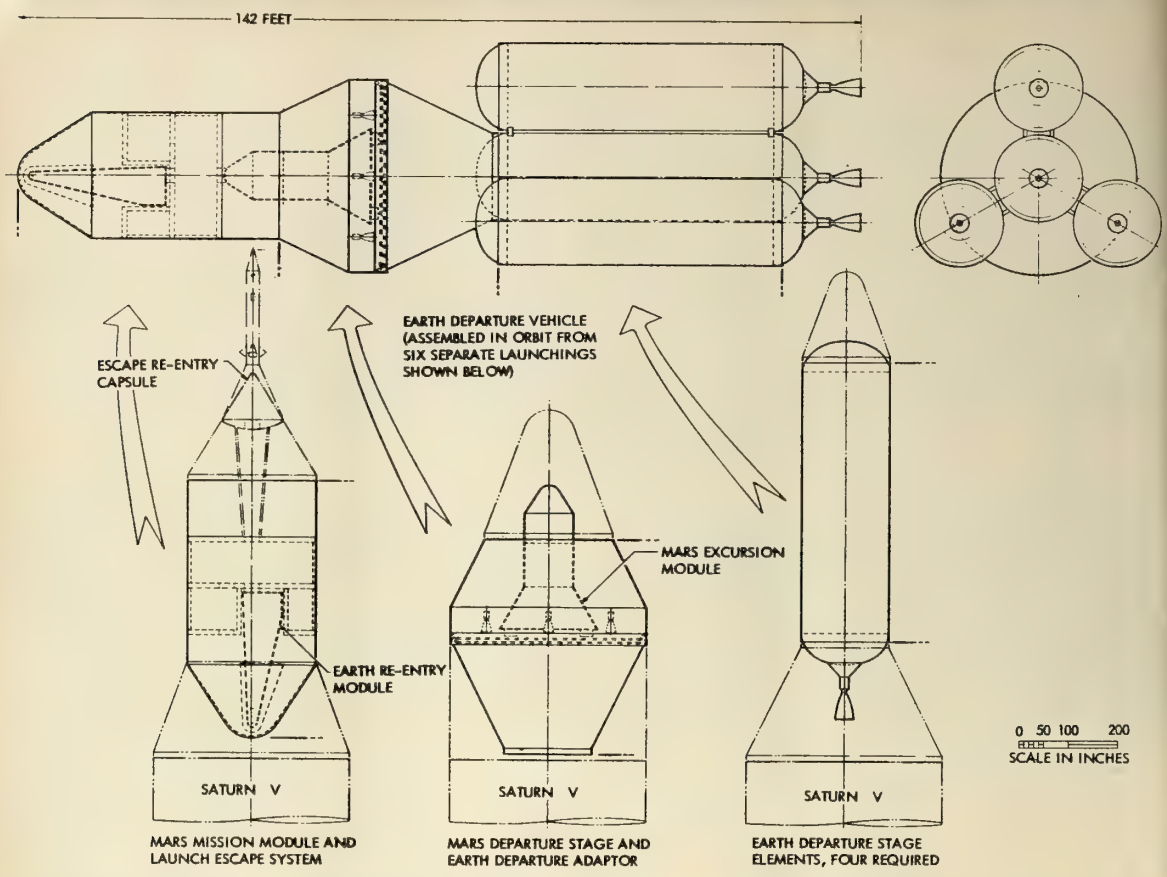
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LAUNCH ARRANGEMENT—with clustered Earth departure stage—for manned Mars spacecraft.

spacecraft gross weights in Earth orbit by a factor of at least two.

• **Comparison with direct mode**—Robert L. Sohn, STL study director, reported that advantages of the Venus swingby mode can be demonstrated by comparing it with the direct mode for a typically unfavorable year, 1975. Using the direct mode would result in an Earth-entry velocity of 65,600 fps. But if the return trajectory were adjusted slightly so the spacecraft made a dark-side passage of Venus at an altitude of about 3,300 km, Earth-entry velocity would be 44,000 fps.

From 1971 to 1999, Sohn reports the proposed Venus return mode is achievable in 9 of 14 opportunities, with no increase in propulsion requirements, since Mars landing missions are found to be very flexible in regard to achieving a rendezvous with Venus. During the period of mission opportunities considered, it was found that about 75% of missions could use swingby to reduce Earth-entry velocities.

If hydrazine is used to shield the spacecraft's command center from solar flares, it could double as a retrorocket fuel to provide the means of reducing Earth-entry velocity even further, down to the *Apollo* system level.

The Venus swingby also can be achieved on the outbound trip from Earth, but in this instance Venus would be used to accelerate the spacecraft toward Mars with the gravitational whip effect, thus reducing the Earth departure propulsion requirement. Result is the same, with Earth-entry velocity reduced to less than 45,000 fps on return. It may be possible to utilize this mode to cut the spacecraft gross weight penalty associated with unfavorable years, such as 1980, while still maintaining the lower Earth-entry velocity.

• **Advantages outnumber drawbacks**—STL notes no adverse effects of the Venus swingby mode in most cases. At any rate, advantages far outweigh the disadvantages, according to Sohn. Advantages include an inspection of Venus during a Mars mission. Two disadvantages noted: an increase of 15-20% in trip time, and a more complex mission profile.

At the same time, however, Earth- and/or Mars-launch holds can be accommodated, and navigation requirements for the Venus gravity turns are no more stringent than for aerodynamic entry at Mars or Earth.

The spacecraft design developed during the STL study was of a central mission module of 260-in. diameter, containing the basic crew quarters, Earth-entry module and, in the case of the stopover mission, a Mars Excursion Module (MEM) housed in the main spacecraft.

Aerodynamic deceleration was assumed for the MEM, with terminal touchdown accomplished by parachute and retrorocket.

Mars stopover missions could be "converted" to Mars flyby missions with use of moderate powered turns during the Mars passage, STL suggests. Spacecraft arrivals and departures from Mars are near the aphelions of transfer



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Our research group directed its effort to meet these military requirements by the utilization of data compiled in conjunction with our commercial programs.

Diesel Power and the Bathtub Curve

Prior work included examination of published studies of pre-wearout failures in compound machines. Dr. Morris, of Imperial Chemical Industries, Ltd., had identified two types of failure faults, Stage I and Stage II.

Initially we plotted failure fault curves. These were established by detailed studies of field service reports of engine failures and basic engine test programs charting failure events as they occurred.

Analysis and comparison of these curves with the Bathtub Curve, familiar to reliability people, revealed a mathematical relationship. We then established the bathtub, or failure rate, curve for Caterpillar Engines.

A Predictable Pattern

In our test and study program we found, right at the start, the Stage I faults—the few with high probability of occurrence—did happen as predicted. These were often traced to human error. Some components were predisposed to fail in Stage I. In diesel generator sets, for example, special relays and diodes of 50% more capacity were added to the control circuit. Hose clamps were replaced by sealed flange joints. Gauges were removed completely. Instead, engine inspection kits include a full set of test gauges.

New Designs Required

Ultimately, analysis of potential failure points revealed the need for designing additional capacity oil and air filter systems and an entirely new cooling system. These changes, with attention to detail, were, in terms of the reliability objective, highly rewarding.

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From this reliability program have come significant benefits to the research for a new VHO engine family for tactical and logistical vehicles. The battlefield reliability standard for these engines was set at .95 for 500 hours—without major breakdown. This Research project for ATAC is already in the building stage.

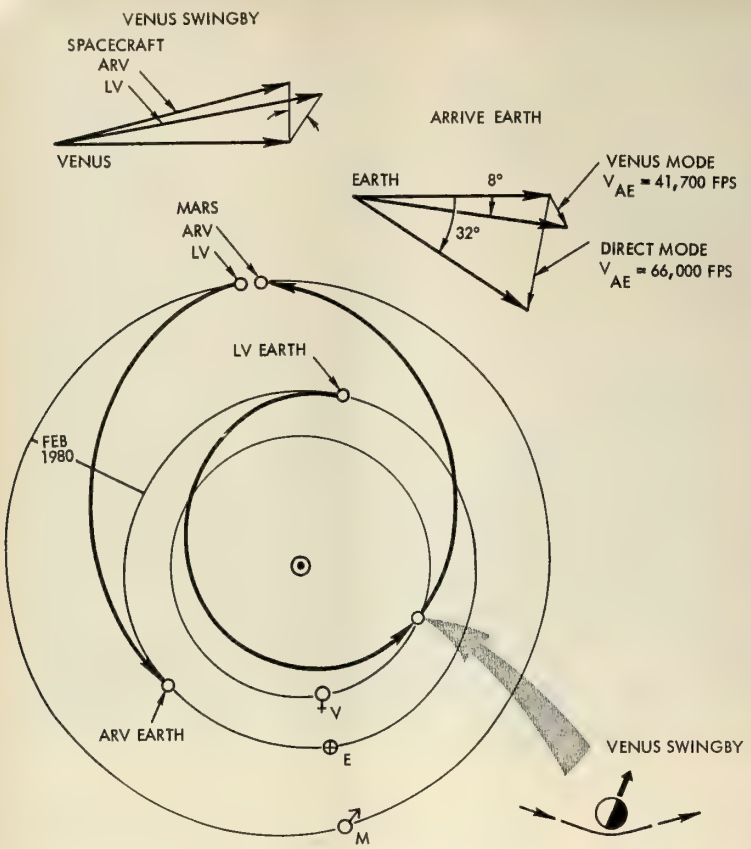
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VENUS SWINGBY outbound mode, as envisioned for a mission projected during 1980.

trajectories, and velocities are rather low during passage.

Most of the turning maneuvers would be accomplished with use of the planet's gravitational field, but generally must be augmented with propulsion. The powered turns would vary between 1,600 and 5,000 fps.

For the flyby modes, the Venus swingby technique is used to reduce both Earth departure and Earth return velocities to values much lower than those associated with direct flyby modes. The results of STL's study of flyby missions utilizing swingby and powered turns at Mars indicate the Earth departure plus powered turn propulsion requirements do not exceed 20,000 fps over the cycle of favorable to unfavorable mission opportunities. Direct flyby requirements reach 30,000 fps. At the same time, Earth-entry velocities do not exceed 48,500 fps for swingby modes, but reach 54,500 fps for direct modes.

● **Design weights**—Design analysis indicated a total spacecraft weight in orbit of about 440,000 lbs., allowing for launch holds, navigation corrections, and solar radiation and micrometeoroid shielding. This included an *Apollo* Earth re-entry module modified for six men, with additional material added for entry velocity of 40,000 fps; a mission module structure weighing 17,186 lbs., and a command center shielded with 11,254 lbs. of hydrazine for radiation protection.

The spacecraft could be launched into Earth orbit with one uprated *Saturn V*, or with two conventional *Saturn V* vehicles. The spacecraft propulsion system was assumed to use two Lunar Excursion Module (LEM) engines.

● **Factors affecting schedule**—The study pointed to two factors affecting the schedule for manned Mars missions. One is the *Apollo* program, which allows no large funding for manned interplanetary missions through the 1960's with the possible exception of the *Manned Orbiting Laboratory* (*MOL*) program. Here it makes a distinction between *MOL* and more elaborate stations, regarding the latter as unnecessary to support the manned Mars missions.

The other factor strongly affecting the schedule is the degree to which the *Apollo* system can be utilized. Spacecraft gross weights in Earth orbit can be reduced to about 1.5 million lbs., with all-chemical propulsion, if aerodynamic braking is feasible at both Mars and Earth.

The Manned Space Flight Center currently is studying uprated versions of the *Saturn V*, which would reduce to three or four the launches required.

"If, in addition to aerodynamic braking at Mars, a Venus swingby mode is used to reduce Earth-entry velocities," reports STL, "the *Apollo* Earth-entry system can be utilized. Hence a manned Mars stopover mission can be achieved with the *Saturn V* launch system, all-chemical spacecraft propulsion (J-2, RL-10, LEM engines) and an *Apollo* Earth entry system."

If an early *Manned Orbiting Laboratory* were in operation by 1970, allowing design criteria to be developed for the Mars flyby mission, a flyby could be scheduled for 1975, the study suggests, if *Apollo-Saturn* equipments and operations were utilized to a high degree. The Mars stopover mission would be scheduled for the 1980 opportunity.

● **Developmental sequence**—The STL investigation suggests the following sequence of developments:

—The *Apollo* system is developed, yielding the Command Module, a life support system, and orbital rendezvous operational techniques, and the *Saturn V* launch vehicle (in development).

—An extended duration *Apollo* Command Module, life support system and mission module (which replaces the LEM vehicle) is developed as an early manned orbiting laboratory, yielding design criteria for the flyby mission. (This step is in detailed study phase, in more than one form in industry, including North American).

—A manned Mars flyby vehicle would be developed using a modified *Apollo* Command Module, an enlarged life support system, and an enlarged mission module (with new subsystems). A single uprated *Saturn V* launcher would be used, or two standard *Saturn V* launchers in an Earth-orbital rendezvous mode. (This is in the feasibility study stage.)

—A manned Mars stopover vehicle would be developed using a modified *Apollo* Command Module, the Mars flyby life support system and mission module, a new Mars excursion module, and three to four uprated *Saturn V* vehicles in an Earth-orbit rendezvous mode. (This is in the feasibility study stage, with emphasis being given to the Mars flyby mission using *Apollo* equipments wherever possible.) ■

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The MB sweep random control permits the reproduction of higher level acceleration density tests and higher pay load tests than the wideband system. Write to MB Electronics, A Division of Textron Electronics, Inc., 781 Whalley Avenue, New Haven, Connecticut, 06508.

MB ELECTRONICS

Circle No. 7 on Subscriber Service Card

RCA Takes Aim on Big Computer Sales

'Spectra 70' Series is designed in four systems increasing in speed, capacity and cost; first will be deliverable in year

by Charles D. LaFond

PALM BEACH GARDENS, FLA.—Radio Corporation of America made its bid here last week for a bigger portion of the high-speed high-capacity computer market during the next decade.

Offering four new systems, two of them employing up to 75% semiconductor integrated circuits, and 40 supporting subsystems, the firm has challenged the industry leaders with a leapfrog technological advancement designed to compete economically system for system. Formal announcement was made here by RCA President Dr. Elmer W. Engstrom.

The series, dubbed Spectra 70, includes systems 70/15, 70/25, 70/45 and 70/55. The first two employ discrete electronic-component circuitry; the latter two have been designed to include monolithic integrated circuits in 75-80% of the logic circuitry.

Cost of the new series will vary widely. The lower-speed 70/15 processor will rent for $800 per month, the complete system for about $2,000 per month. Outright purchase price will be about $100,000.

For the largest system, the 70/55, monthly processor rental will be $22,500, purchase price more than $1 million. Estimated total cost for the complete big system will undoubtedly exceed $2 million and could easily stretch to $3 million, depending on periphery-equipment requirements.

Designed for a multilingual system series, the digital equipment will be compatible both within its own systems and with the existing RCA 301, 501, and 3301, the IBM 1401 series and its antecedents and the newer 360 series. Both COBOL and FORTRAN programming languages will be acceptable to Spectra 70 equipment, said RCA officials.

First component design and development for the new series began in 1963 for the 70/15 and 70/25 systems. In 1963-64, with the decision to go with an eight-bit code and integrated-circuit design, the 70/45 and 70/55 system designs were initiated. However, it was not until this year that final designs and breadboarding were completed on the whole series of equipment.

As of now, only the smaller 70/15 system prototype has been completed. RCA disclosed with the announcement of its Spectra 70 series that the 70/15 and 70/25 systems will be deliverable in 12 months and the more advanced, larger systems in 18 months. All systems, said RCA officials, are in production now—at least on a subsystem basis—in Camden, N.J., and here in the Palm Beach Gardens Electronic Data Processing Div. plant.

- **Technical details**—Memory cycle speeds of the Spectra 70 data processors vary from 2 microseconds (70/15) to 840 nonoseconds (70/55). Memory sizes vary from 4096 bytes (eight bits per byte) to 524,288 bytes, respectively.

The 70/15 processor is a general-purpose computer designed for small

SILICON CHIP (center) used by RCA is 1/20 in. on a side, holds two complete computer circuits that would normally require 28 separate components to function.



data systems applications, remote terminals, and other limited applications such as satellite support. It is a character-organized, two-address system that extracts and restores data to memory one byte at a time—one alpha-numeric or two decimal digits, or binary. Each character is handled as EBCDIC—extended binary coded decimal interchange code.

The 70/25 general-purpose computer employs a stored program of a variety of applications. Similar to the 70/15 but more powerful, it has a 1.5-microsecond-per-byte memory cycle and four bytes can be extracted and restored at a time. Up to 123 terminals and peripheral equipments can be operated on line with the system.

Designed for medium to medium-large operations, its memory is field-expandable from 16,384 bytes to 65,536.

The 70/45 general-purpose processor employs a stored program and is designed to be used in a small-to-medium-scale integrated computer system. It has a rated memory speed of 1.44 microseconds per 16 bits. Four optional floating-point 64-bit registers are provided.

By employing an intermix of input/output equipment up to 11-way simultaneity can be obtained. Forty-three general-purpose 32-bit registers are provided by a 300-nanosecond scratch-pad memory.

Designed for use in such applications as communications control and scientific-data handling, the 70/45 is considered by RCA to be suitable for large-scale range at relatively low cost with respect to performance.

The 70/55 processor—largest of the series—is a word-organized system utilizing a stored program and designed as a medium-to-large integrated management system. Its very fast memory cycle (840 nanoseconds for four bytes) is coupled with memories ranging from 65,536; 131,072; 262,144; or 524,288 bytes. Fixed-length data of 8, 16, 32 or 64 bits may be processed and variable-length data of up to 256 characters (in 8-bit increments) may be handled.

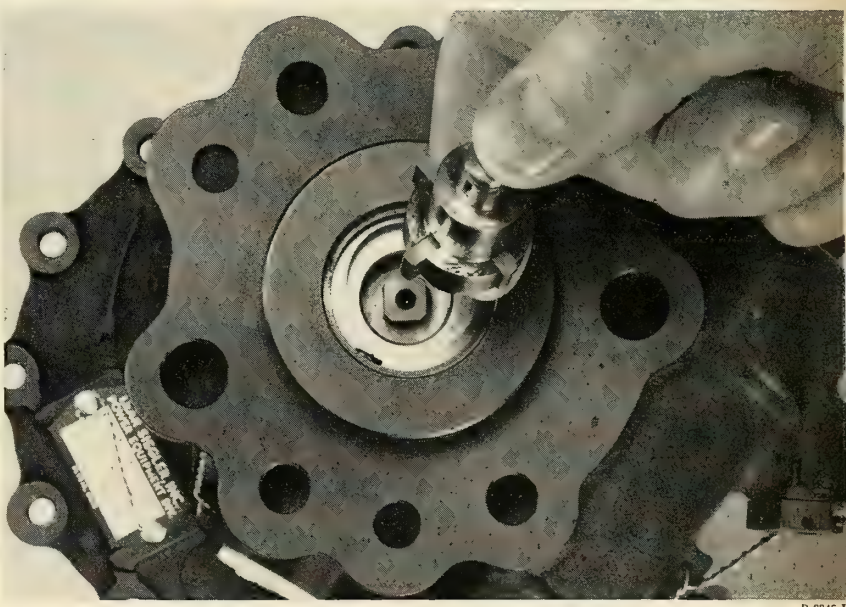
The 70/55 is capable of handling all electronic data-processing needs, RCA says. Also, developers say, the system's storage capacity, coupled with a 14-way simultaneity and parallel logic, assures a system applicability to the total management operation.

● **Use of SIG's**—The Spectra 70 series is believed to be the first broad employment of semiconductor integrated circuits (SIG's) in commercial hardware.

Measuring only 0.050 in. on a side, each silicon chip carries up to 15 transistors and diodes and 13 resistors. Each chip contains two complete computer logic circuits. ■



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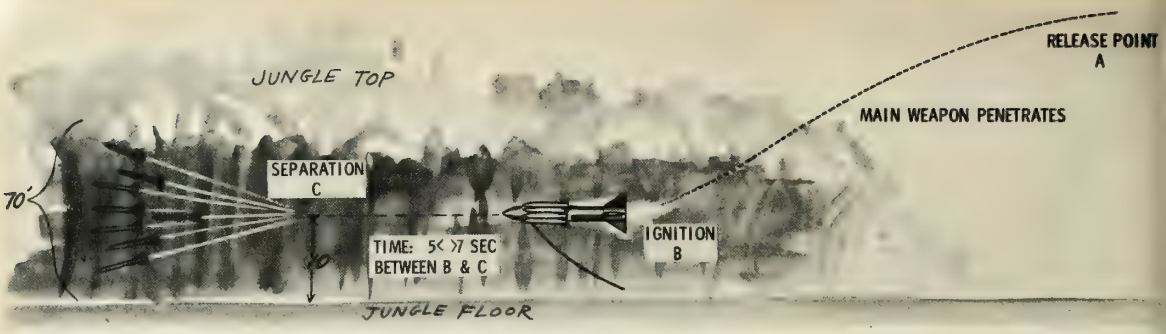
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AFTER RELEASE from airborne platform, anti-guerrilla weapon penetrates tree area using "laser radar" and releases projectiles.

missile systems

Low-Cost Missile Has Dual Capability

Air Force is beginning exploratory development of $1,000 multi-warhead tactical missile able to hit tanks, seek out guerrillas

by William S. Beller

A LOW-COST tactical missile with multiple warheads, able to flush out guerrillas in a forested area or destroy a tank, is going into exploratory development in the Air Force.

As an anti-guerrilla device, the missile would penetrate a forest at a low level, avoid trees by means of laser guidance, and discharge its multiple warheads either at a programmed time or possibly by means of infrared detection of the enemy troops.

As an anti-tank device, the missile would be aimed visually from a fixed-wing aircraft or helicopter platform and discharge its warheads in a pattern that would best ensure "killing" the ground vehicle. If the tank, for instance, were proceeding along a straight-away, the pattern would be an elongated rectangle pointing down the straight-away. If the path were a sharp curve off the road, the warhead pattern would be a circle.

The cost of the complete missile with six or seven "satellite" projectiles is estimated at $1,000—a conservative figure according to a spokesman for the project who said he sees the missile possibly costing as little as $300. Regardless of which figure is used, the effect would be to get an extremely favorable cost/effectiveness figure based on the dollars needed to "kill" a given number of square feet in a tactical engagement.

The anti-guerrilla version of the missile, called "Big Marc," and the anti-tank version, "Big Bill," culminate two years of personal research on the concepts by Lt. Col. W. C. Athas, Chief, Electronics Div., Air Force Office of Scientific Research. He was helped in some of the details by several Air Force R&D groups as well as by industry.

If the weapon's guidance system lives up to its promise, "the missile as an anti-tank weapon could be a significant advance in the state of the art," says Col. Charles C. Smith, Jr., Chief, Reconnaissance & Guidance Div., Air Force Systems Command's Research and Technology Div.

Smith made this statement in a report recommending that RTD pursue development of the guidance system and low-cost rocket engine, and include the project in the agency's exploratory development program.

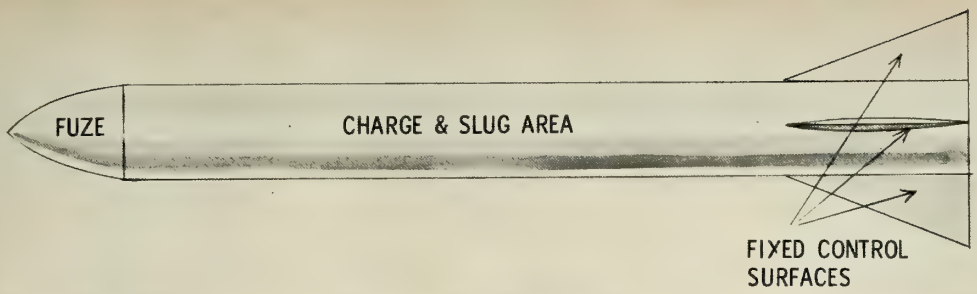
Athas recommends that unsolicited proposals from industry for such development be forwarded to the appropriate laboratories at Wright-Patterson AFB, Ohio: Avionics, Flight Dynamics and System Analysis Directorate; and Detachment #4, RTD, at Eglin AFB, Fla.

• **Anti-tank weapon**—The anti-tank missile is launched at relatively high speeds compared with the anti-guerilla missile. Both weapons, though, use a fully coherent radiation detection and guidance system employing an active continuous wave gas laser and four coherent solid-state detectors. These detectors or sensors generate the signals that actuate miniature paper vector control rockets, which aid in steering the missile to its target.

In an actual tank attack, the airplane pilot visually sights on his target. He can be in error as much as twelve degrees and still have a high probability for a kill. A simple two-degree-of-freedom, gas-actuated plastic gyro built by American Gyro of Los Angeles furnishes roll and stabilization information at launch and during the flight.

• **Guidance**—From the time the pilot pushes the fire button for ignition of the sustainer rocket until the weapon reaches midcourse, the missile is unguided and is stabilized only aerodynamically. At midcourse, however, the laser beam, which may be split by means of mirrors or other devices, is reflected by the tank and picked up by a sensor array on the nose of the missile. This laser return may also be reinforced by the infrared emissions of the tank itself.

The pattern of the laser returns on the sensor array determines the needed corrections to the missile trajectory as well as the required dispersion of the satellite projectiles. The corrections are put in by suitable firings of small discrete power packages of solid propellants, acting somewhat like a string of separately ignited firecrackers. These



"SATELLITE" PROJECTILE is lightweight, low-cost weapon with plastic body and proximity fuse.

are situated to give corrections in yaw while servo-actuated elevons give corrections in pitch and roll.

At the same time, the harness holding the satellite projectiles is adjusted by automatic means to give the dispersal pattern called for by maneuvers of the target.

● **Primary propulsion**—The main propulsion system is a low-cost paper rocket engine weighing between 125 and 150 lbs. fully loaded with propellant. It is being developed by the Elkton Div. of Thiokol Chemical Corp. as an internal research project and was made available to Athas together with the small steering rockets.

Philco's Blue Bell Laboratories constructed the fundamental solid-state coherent radiation detectors and coopperated with Athas in the design of the logic used in the detection system. Prof. Nicholas George of the electrical engineering department, California Institute of Technology, set up the preliminary experiments to evaluate the logic of the detection and guidance systems.

● **Anti-guerrilla weapon**—The antipersonnel missile will be dropped from an airplane or helicopter traveling at 100 to 200 knots. Athas says that the standard 100-lb. bomb rack and release system would be used.

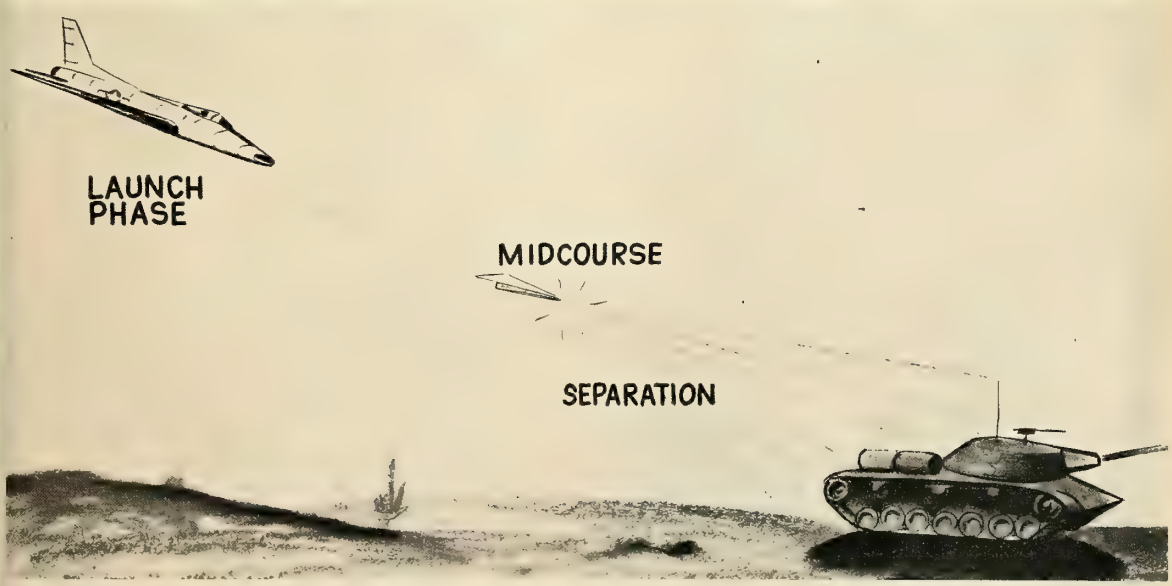
The missile, weighing about 125 lbs., the same as the anti-tank weapon, would be of the approximate form factor as a 100-lb. bomb. Release would occur at altitudes varying from about 500 ft. down to tree-top level. The missile would travel in a ballistic trajectory until it reached a specified altitude, which could be between 40 and 50 ft. above the ground. Then, the missile would level off and fly horizontally.

The time at which pull-out is initiated would be determined by an optical altimeter and would be accomplished by aerodynamic lift provided by snap-out wings supplemented by solid-rocket thrust.

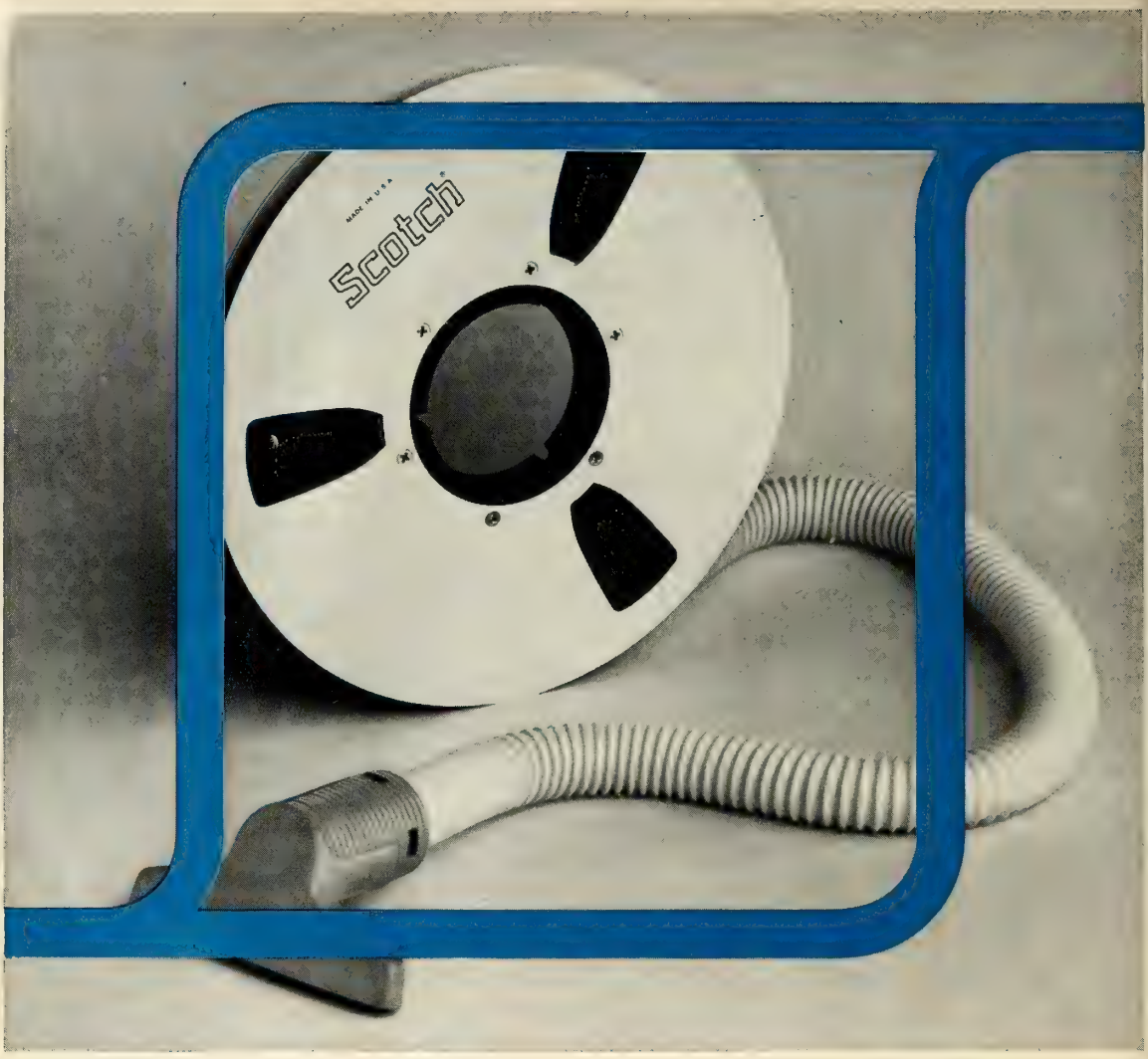
After leveling out, the missile with terrain-following guidance would continue to be propelled for several more seconds of flight. Velocity would probably be below 150 knots and even as low as 50 knots in order to keep the structure intact while making the turns needed to avoid ground obstacles.

● **Tree dodging**—To do such dodging, the missile will contain a "laser radar" type system. The advantage of such a system, according to Athas, is that its unambiguous return signal results in the smallest possible logic system for guidance signals. Athas admits that some confusion might be introduced by foliage, but he is confident that this can be filtered out.

He also expects that the laser detectors, working in the IR range, will be able to recognize the pattern of guerrilla concentrations or encampments or will be able to home in on ground fire. At this point, the multiple warheads would be dispersed and grenade-type shot or other debilitating material scattered. ■



ANTI-TANK WEAPON is aerodynamically stabilized to midcourse, then is laser-guided to target.



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TECHNICAL TALK Bulletin No. 4 offers detailed discussion of static-caused problems in instrumentation recording, helpful information for solving them. Free. Write 3M Magnetic Products Division, Dept. MBW-124, St. Paul 19, Minn.

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Mergers and Acquisitions

Stoddart Electro Systems Div. of Tamar Electronics, Inc., Los Angeles, has acquired the Auto-Pilot Controller product line of White Electromagnetics, Inc., of Rockville, Md. In addition to the APC product line, Stoddart has contracted for the consultation services of D. R. J. White, president of White Electromagnetics, and originator of the APC for a period of two years. Stoddart makes RFI measuring instruments, RF attenuators and terminations, amplifiers, demodulators and a line of impedance stabilization networks. . . . *Dynamic Associates of Burlingame, Calif., has acquired Ault Associates, a California electronics representative. With the additional personnel and facilities, Ault intends to expand its territorial coverage to include all of California, Arizona and Nevada.* . . . CTS Corp., Elkhart, Ind., and The James Knights Co. have merged, with James Knights Co. stockholders to receive 130,527 shares of CTS stock for their Knights holdings. The Business of James Knights Co. will be carried on in Sandwich, Ill., by CTS Knights, Inc., a new wholly owned subsidiary of CTS. CTS makes variable resistors, loudspeakers and microelectronic components and circuits. James Knights made quartz crystals, crystal controlled oscillators and crystal filters. . . . *Allegheny Ludlum Steel Corp., Pittsburgh, has agreed to acquire Special Metals, Inc., New Hartford, N.Y. Special Metals manufactures high-temperature alloys. Allegheny Ludlum is to exchange 96,311 shares of its capital stock valued at approximately $4 million for the 418,955 capital shares of Special Metals. Special Metals stockholders will vote on the acquisition Dec. 21.*

Missile/Space Facilities

Groundbreaking for a new Consolidated Computer and Control Center building for White Sands Missile Range, N.M., is scheduled to occur early next year. The facility will permit consolidation under one roof of several range functions presently being performed in separate buildings, some at considerable distances apart. The building will be windowless to provide a nearly dust-free atmosphere and more level illumination. It will provide the nerve center for White Sands Missile operations and will become part of the range readiness reporting subsystems, presently under development, to give almost automated control, as opposed to oral and manual systems now in use at WSMR. . . . *Honeywell, Inc., has purchased a 162,000-sq.-ft. facility in Waltham, Mass., from Clevite Corp. The new building will be used by the firm's electronic data processing division in consolidating into a single location its engineering, research and development groups. The 36.5-acre tract of land bought with the new building and located only seven miles from Honeywell's Wellesley Hills EDP headquarters complex, will provide room for expansion after 1965* . . . . Silicon Transistor Corp., Carle Place, N.Y., manufacturer of semiconductor products, has announced plans to move its offices, engineering divisions and all production activities to a 51,000-sq.-ft. site in Garden City, N.Y. Silicon presently operates from six separate buildings on four sites. All activities except those in its Union, N.J., R&D facility will be consolidated in the new facility. . . . *Crest Ultrasonics Corp., Trenton, N.J., has announced plans to expand its facilities by 10,000 sq. ft. The additional space will be used to accommodate increased manufacturing activities and to accelerate the firm's new product development in the area of a mass produced general purpose ultrasonic cleaning system for a variety of markets.* . . . Luvak, Inc., Newton, Mass., has acquired the Vacuum Fusion Laboratory of National Research Corp. in Cambridge, Mass. The facility's five vacuum fusion analyzers and related equipment will be moved by Luvak to Newton where it will be incorporated into a new service facility serving government and industry.

New Activities

Micro-Optics, Inc., has been formed in Waltham, Mass., to concentrate on the development and manufacture of a proprietary line of microwave and optical diodes. The company has begun operation in leased quarters. A move to larger facilities is anticipated within the next six months. The management group has furnished the initial operating capital, but negotiations are in process for additional capital. The product line is to include solid-state light sources, injection lasers and photo-detectors, crystal mixers and detectors, varactor diodes and special purpose diodes for switching, limiting, parametric amplification and harmonic generation. . . . *The Bendix Corp. has consolidated all activities of Microwave Devices, Inc., into a newly completed facility in Farmington, Conn. The Farmington plant will contain the general management, engineering, sales, and manufacturing functions formerly located in Bristol, Conn., and Rockville, Md.* . . . Avnet Electronics Corp. shareholders have approved a shortened name for the company. The New York City diversified electronics firm will become known as Avnet, Inc.

International

Standard Telephones and Cables Ltd., British subsidiary of International Telephone and Telegraph Corp., has formed a new STC Data Systems division to market and expand its interests in advanced on-line real-time record communication message switching systems and other computer-based system applications. . . . *Block Engineering, Inc., Cambridge, Mass., has acquired a 49% interest in Rehovoth Instruments, Ltd., Rohovoth, Israel. Rehovoth is active in research and development and fabrication of electro-optical instrumentation.*

AIR FORCE

$4,500,000—**The Boeing Co.,** Seattle, for continued research work on the *Minuteman* missile program.

$3,180,000—**Lockheed Aircraft Corp.,** Sunnyvale, Calif., for continued work on the *Gemini* program.

$2,101,442—**Geotechnical Corp.,** Garland, Tex., for work on a classified project.

$1,504,140—**Laboratory for Electronics Inc.,** Boston, for production of Doppler radar set components.

$1,500,000—**Areojet-General Corp.,** Azusa, Calif., for an advanced research facility for studying respiratory toxic hazards such as would be encountered in prolonged exposure to closed atmospheres and traces of various contaminants in space cabins.

$1,350,000—**Space-General Corp.,** El Monte, Calif., for design, manufacture and testing of unspecified satellite payloads.

$1,310,370—**Radio Corp. of America,** New York City, for continued work on a voice-communication switching system.

$1,300,000—**Analytical Services, Inc.,** Alexandria, Va., for analytical studies on strategic, tactical and air defense weapons systems.

$1,236,227—**Sperry Rand Corp.,** Phoenix, for production of components for a gyroscopic compass system.

$89,695—**Vitro Corp. of America,** Vitro Services Div., New York City, to supply a van-mounted radar data-handling system to be used in conjunction with a high-resolution tracking radar, which is a modified version of a *Nike* target tracking radar.

$38,200—**Lockheed Aircraft Corp.,** Lockheed Missiles & Space Co., Sunnyvale, Calif., for numerical investigation of electromagnetic scattering and diffraction by convex objects.

ARMY

$19,055,953—**George A. Fuller Co.,** Los Angeles, for construction of Pad B, Launch Complex 39, NASA's Merritt Island Launch Area, Fla.

$9,342,744—**Mason & Hanger,** Silas Mason Co., Burlington, Iowa, for artillery projectiles and *Hawk* missile warheads.

$7,379,000—**Western Electric Co.,** Syracuse, N.Y. and Burlington, N.C., for work on *Nike-Hercules* system.

$2,000,000—**Martin Co.,** Orlando, Fla., for initial work on the design and development of improved *Pershing* weapon system ground support equipment.

$65,850—**Lockheed Propulsion Co.,** Redlands, Calif., for continuation study on combustion of solid propellants.

$49,596—**Texas Instruments, Inc.,** Dallas, for study of a terminal guidance technique for short-range artillery missiles.

NAVY

$6,100,100—**TRW/Space Technology Laboratories,** Redondo Beach, Calif., for systems analysis and engineering work in support of an ASW program. Work will be done in Washington, Los Angeles and various Navy bases.

$2,506,807—**General Electric Co.,** Ordnance Dept., Pittsfield, Mass., for operational support for fire-control guidance and support equipment for *Polaris* FBMs.

$2,380,589—**TRG, Inc.,** Melville, N.Y., to demonstrate the feasibility of an advanced sonar system.

$1,682,101—**General Dynamics Corp.,** Rochester, N.Y., to demonstrate the feasibility of an advanced sonar system.

$1,524,596—**Sperry Rand Corp.,** Sperry Gyroscope Co., Great Neck, N.Y., for *Polaris* Mk-1 pulsed integrating pendulems.

$1,314,589—**Westinghouse Electric Corp.,** Baltimore, for continued work on missile-control system for *Phantom II* fighters.

$199,000—**Radio Corp. of America,** Missile and Surface Radar Div., Moorestown, N.J., for modification of AN/FPS-16 radars.

$149,102—**C-E-I-R, Inc.,** Sunnyvale, Calif., for analytical and programming services in the fields of reliability and accuracy analysis on the *Polaris* FBM program.

$118,572—**Baldwin Electronics, Inc.,** Little Rock, Ark., for influence fuse for *Sidewinder 1A* missile.

NASA

$1,600,000—**Lear Siegler, Inc.,** Santa Monica, Calif., follow-on contract to provide electronic instrumentation and control systems for the George C. Marshall Space Flight Center.

$1,151,370—**Hughes Aircraft Co.,** Research Labs, Malibu, Calif., for ion engine development.

$243,061—**Hughes Aircraft Co.,** Research Labs, Malibu, Calif., for porous ionizer evaluation.

$215,250—**Advanced Technology Corp.,** Timonium, Md., for submillimeter satellite radiometer.

$150,000—**Government of Spain,** Instituto Nacional de Technica Aerospacial, Madrid, Spain, for tracking facility operation and maintenance.

$140,000—**Leach Corp.,** Los Angeles, for design and development of an instrumentation tape recorder/reproducer for use on *Saturn*.

$124,578—**Avco Corp.,** Tulsa Division, Tulsa, Okla., for a 10-month investigation of various materials and components used in the manufacture of spacesuits.

$94,675—**Lockheed Missiles & Space Co.,** Palo Alto, Calif., for study of reentry configurations for manned space vehicles entering the Earth's atmosphere at hypersonic speeds.

$79,682—**Bendix Corp.,** Systems Div., Ann Arbor, Mich., for study of mineral stability in the lunar environment.

$71,000—**Cornell Aeronautical Laboratory,** Buffalo, N.Y., to develop and construct a prototype of a radically new scanning device that requires no vacuum tubes.

$65,664—**Cuthrell Machine & Steel Corp.,** Chesapeake, Va., for practice recovery of spacecraft boilerplate models.

$49,584—**Lear Siegler, Inc.,** Instrument Div., Grand Rapids, Mich., for development of crew station design guide.

$42,500—**Operations Research Inc.,** Silver Springs, Md., for studying and recommending techniques to be used in status evaluation of the NASA Space Tracking and Data Acquisition Network (STADAN).

$36,826—**Exotech, Inc.,** Alexandria, Va., for definition of requirements for advanced sterilizable components for planetary spacecraft.

$35,000—**Radio Corp. of America,** Victor Co. Ltd., Research Labs, Montreal, Canada, for laboratory simulation of the interaction between solar wind and the magnetosphere.

Arthur D. Little, Inc., Cambridge, Mass., to build and test in a simulated solar environment a one-half scale model of a prototype thermal mockup of the *Mariner* Mars 64 spacecraft (amount undisclosed).

INDUSTRY

$1,000,000—**Computer Control Co.,** Framingham, Mass., from **North American Aviation Inc.,** Canoga Park, Calif., to produce data-acquisition and processing systems for use in connection with rocket engine tests.

Military & Computer Electronics Corp., Ft. Lauderdale, Fla., from **Radiation Inc.,** Melbourne, Fla., for requirements for the manufacture of miniature high-reliability components for use in Project *Apollo* (amount undisclosed).

America's vital space centers...

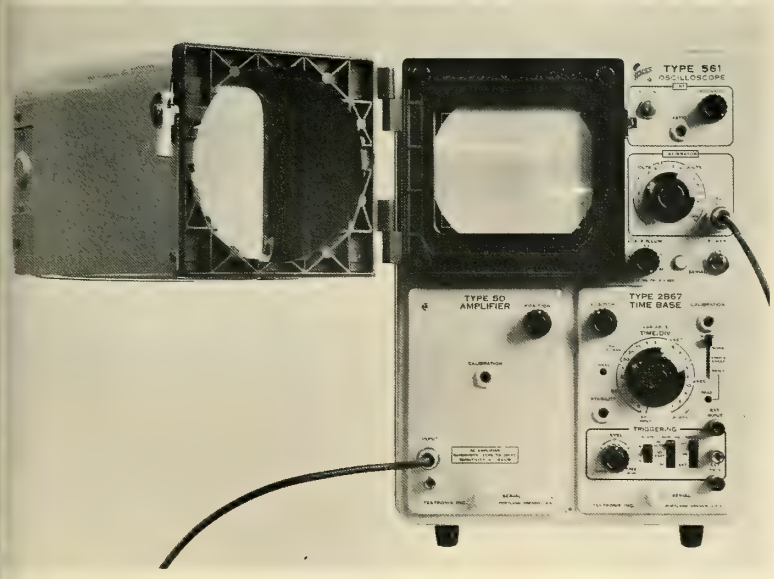


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New Product of the Week: Image Expander

The StereoRamic Image Expander, an optical instrument that improves screen images on standard CRT oscilloscopes and similar measuring devices, is available from Ednalite Research Corp.

The device enlarges the standard 19.6-sq.-in. screen to 48 in. with marked intensification in relative brightness of the CRT trace, the firm says. Traces and grids are enlarged to double size without distortion, and viewing angle is expanded.

The unit features non-magnetic hardware and aluminum frame and wraparound housing.

Circle No. 151 on Subscriber Service Card

Electro-Optical Monitor

Chrysler Corp.'s Missile Div. is marketing an electro-optical twist angle monitor, or optical synchro, designed to continuously measure small angular rotation with an accuracy of 1 arc-sec.

The monitor consists of a transceiver, passive reflector and readout. It reads directly in seconds of arc with one graduation for each two arc-seconds.

Specifications include: an angular range of ±50 arc-seconds; sensitivity of 0.1 arc-sec.; operating distance of 4 to 20 ft. (automatic gain control) or 4 to 40 ft. (manual gain control); recorder output of 3,000 ohms; and power of 110v, 60 cps.

Circle No. 152 on Subscriber Service Card

Carbon Material

A material, Carb-I-Tex, produced by bonding layers of one or more fiber forms of carbon or graphite, is available from Basic Carbon Corp. The material is 3.5 to 7 times stronger than the best grades of graphite presently used in high temperature metallurgical and aerospace applications, developers say.

The material is said to increase in strength with increasing temperature until it is approximately two times stronger at 4,200° F than its room temperature compressive strength of 45,000 psi. Large blocks of the material have been dropped on concrete from a height of 20 ft. without fracture, the firm reports. It is directly formed to finished shapes and can be machined.

In addition to high strength, Carb-I-Tex features a density of 1.4 gr/cc, is immune to thermal shock and dimensionally stable to 5,700° F. It has no melting point, is considered corrosion proof, electrically conductive and will not emit gasses.

The material is designed for missile and ballistic nozzles, leading edges and ablative structures on aerospace vehicles. It can also be used as a combinational structural/shielding material for nuclear reactors.

It is presently available in small diameter round shapes and flat plates, using carbon cloth and a carbon bond to produce an all-carbon material.

Circle No. 153 on Subscriber Service Card

X-Ray Diffraction Chamber

An X-ray diffraction chamber which uses a stream of electrons as its heat source is being marketed by MRC Manufacturing Co. The Model XEB-101 was designed under contract to the Air Force for study of re-entry materials and is especially adapted for examination of relatively large samples.

The unit can deliver temperatures as high as 3,000°C with a power input of less than 50 watts. It was designed for use with X-ray diffractometers for examination of single crystal, polycrystal or powder specimens and can accommodate specimens up to 0.25 in. in diameter. Data may be collected on standard X-ray film or with a Geiger counter. A wide beryllium window permits detection of both zero order and first order layer lines.

The chamber is provided with a complete vacuum system as well as the ordinary high voltage supplies. The specimen is supported by a tungsten-rhenium thermocouple which also serves to measure temperature.

Circle No. 154 on Subscriber Service Card

Refractory Metals

Single crystal metals, including niobium, molybdenum, tantalum, vanadium and tungsten, with purities in the range of 99.99% are available in standard rods from Advanced Research Materials Co.

The refractory metals are available in 0.25, 0.375 and 0.5-in.-dia. rods in lengths up to 6 in. The crystals are grown using electron beam techniques and prepared by the spark erosion process. They are normally supplied with random orientation, but specific orientations are available.

Circle No. 155 on Subscriber Service Card

Rotary Vane Attenuator

A rotary vane attenuator, covering frequencies from 3.95 to 50 gc, is available from Microwave Components & Systems Corp.

The Model 281 is equipped with a cylindrical center section with an attenuating element that rotates from 0 to 90 degrees, and a locking device. Any value of attenuation may be preset and locked until resetting is desired.

Insertion loss is less than 1.0 db and VSWR is 1.15:1 maximum. Variation of attenuation with frequency is ±0.5

db from 0 to 20 db and ±1.0 from 20 db to maximum attenuation. Power handling capacity ranges from 1 to 15 watts.

Circle No. 156 on Subscriber Service Card

Optoelectronic Components

A series of optoelectronic solid-state components, including a gallium arsenide infrared source (Model 4104), a silicon phototransistor (Model 4202) and a PIN photodiode (Model 4201), has been announced by hp associates.

Using photons as the signal carrier, the devices employ fiber optic light pipes to couple the signal from the semiconductor chip to a 0.02-in.-dia. circle on the surface of the glass.

The photodiode has a quantum efficiency of about 0.5 (electrons per photon) and a response time of 0.2 nanosecs. Capacitance is 1 pfd at 20v; breakdown voltage is greater than 200v and reverse leakage less than 2 na.

The phototransistor is a high-gain sensor for photons in the visible and near infrared. Quantum gain is 200; response time is less than 2 ms.

The gallium arsenide diode provides a band of infrared radiation at 0.9 microns that can be modulated at nanosecond rates. External quantum efficiency exceeds 0.001.

Circle No. 157 on Subscriber Service Card

Band Rejection YIG Filter

A band rejection filter, which can be used as a course frequency market in a receiver and in spectrum analyzer applications, has been developed by Loral Electronic Systems.

Available in five models covering an approximate frequency range of 0.5 to 12.4 gc, these two-stage YIG filters offer a sweep rate of 0 to 100 cps. Linearity of the drive current versus frequency exceeds ±0.25%, with a resetability accuracy of better than ±0.25%. Input and output impedance is 50 ohms; operating temperature range is 55° to 85°C. All models meet applicable MIL specifications.

Circle No. 158 on Subscriber Service Card

Voltage Source

Julie Research Laboratories, Inc., is marketing a 1,200-v dc voltage source with 0.005% accuracy. The unit is controlled by a divider, in place of a rheostat, which can be used independently to an accuracy of one part/million.

Accuracy of the calibrator is enhanced by design, the firm says. The 76 resistors are part of a 0.0001% linear divider operating at 12-v maximum stress. Self-calibration of the standard to 0.005% accuracy is accomplished by a resistor string and null detector.

Specifications include: three ranges —0 to 1,200v in 0.0001-v steps, 0 to 120v in 10-mv steps and 0 to 12v in 1-mv steps; resolution of seven digits; output current of 0 to 35 ma; stability of 0.005%, six months, and 0.0025%, six days; load regulation of 0.001% full-scale; line regulation of 0.001% for ±10% line voltage.

Circle No. 159 on Subscriber Service Card

High-Temp Gauge

A high-temperature measuring device with a 5-ms response time has been developed by the Denver Research Institute of the University of Denver.

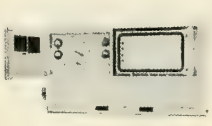
The pyrometer has a temperature range of 1,300° to 3,750°C. Experimental work indicated valid temperature measurements as high as 10,000°C may be obtained with the instrument, the Institute said. Detectors have a 100-kc response; zone of measurement is confirmed by photographing an image of the source at the same time of temperature measurement.

In operation, temperature is measured by the related ratio of energy received in two separate spectral bands.

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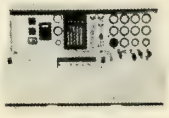
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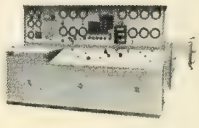
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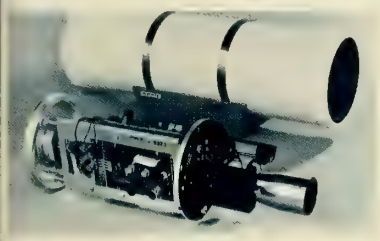
Degree of deviation of the source emittance from a constant is determined by introducing a third band-energy determination. Three independent temperature measurements are obtained from the three indicated energy values. If the ratios of these energies correspond to the same temperature, the emissivity is a constant and the temperature is defined. If they do not, the ratios are used to calculate emittance as a function of wave length. When this is coupled with a monochromatic brightness temperature measurement, a valid source temperature is obtained.

Circle No. 160 on Subscriber Service Card

Camera Lens Controller

A mechanized unit for remotely controlling iris and focus lens functions has been announced by Cohu Electronics, Inc.

Specifically engineered for mounting on the Cohu 3000 series television



camera, the units permit the remote controlling of lenses with fixed focal lengths from 0.5 to 6 in. The optics and drive mechanism are protected by an environment-resistant camera housing.

Circle No. 161 on Subscriber Service Card

Cryogenic Transfer Pump

Pico Precision Products Co. is marketing a medium-pressure cryogenic transfer pump. The device features dry lubricated bearings and elimination of the shaft seal.

The pump is capable of flows to 200 gpm and pressures exceeding 750 ft. of head. Overall pump efficiency of 80% has been achieved in actual performance, the company says.

Circle No. 162 on Subscriber Service Card

Oscilloscope Probe

A transistorized oscilloscope probe for examination of low-level signals is available from W.M.A. Andersen Co., Inc.

The device has a gain of 26 db at input and a bandwidth of 300 cycles to 70 mc. Input impedance is 100,000 ohms shunted by 10 pfd. Power supply operates from 110v, 60 cps. System weight is 23 oz.

Circle No. 163 on Subscriber Service Card

Punch Card Analyzer

Texas Instruments, Inc.'s Industrial Products Group has developed a yield and distribution analyzer for punched card data analyzing.

The Model 858 YADA summarizes data which pass within present limits compared against preset upper and lower values. A yield counter totals the units passing; a device counter totals units compared. The instrument can analyze 3- or 4-digit parameters and will read and compare 72 columns of an 80-column IBM card simultaneously.

Limit programming is accomplished by panel-mounted thumb wheel switches. Two switches are provided for each digit to be compared. The Model 858 is available with optional features including a vertical bar graph display and a double punch alarm system for card code error.

Circle No. 164 on Subscriber Service Card

Particle Inspection Solutions

Recordaflux Products is introducing a line of liquid plastic magnetic particle solutions for use in crack detection and in determining magnetic permeability differences in metal parts.

The solutions set up as a plastic film after the magnetic particles have migrated to cracks, around spot welds and along porosity and non-metallic inclusions. Patterns can be interpreted while the solution is still liquid or when the patterns are frozen. Permanent records are obtained by reinforcing the film with pressure sensitive tape and stripping the record off the surface of the part.

Solutions are available in spray cans and in bulk containers and are used with the existing commercial magnetizing equipment.

Circle No. 165 on Subscriber Service Card

Air Purifier

A series of portable air purifiers, using the laminar-flow principle normally found only in large work stations, has been developed by Atmos-Tech Corp.

The purifiers are capable of trapping 99.97% of all atmospheric impurities 0.3 microns in diameter or larger. Five models are available with overall sizes from 17.75 x 14.75 x 9.25 in. The Model 1212 can provide up to 300 cu. ft. of pure air per minute, providing 20 changes of air per hour for an average 10 x 12-ft. room.

Circle No. 166 on Subscriber Service Card

Cryogenic Panels

A line of cryogenic shrouds and cold traps for use in bell jars from 12 to 24 in. in diameter is available from Dean Products, Inc.

The panels, called CRYOPANEL, condense vapors which might otherwise slowly outgas within the bell jar holding the vacuum level at too high a value for research needs. By installing the cold trap, which has already been tested to a (helium) leakage of 10^{-9} Std cc/sec, the bell jar can be more quickly brought to the proper vacuum, the firm says.

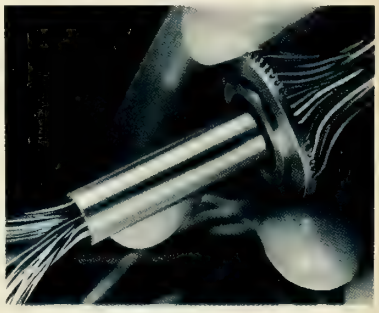
The panel assemblies are weldments of two sheets, either (or both) embossed, then resistance-welded to form flow channels for water, brine, refrigerant, or liquified gases. The product is available in cylindrical shapes, although flat panels and venetian-blind configurations are also offered.

Circle No. 167 on Subscriber Service Card

Slip-Ring Capsule

A miniature slip-ring capsule assembly that can be reduced in length without eliminating any of the 38 circuits has been introduced by the Virginia Div. of Electro-Tec Corp.

Overall length of the capsule, from



mounting face of flange to end of barrel, is 1.35 in. The length can be reduced as much as 0.2 in. by varying the length of the dust cover to meet any size requirements within this range. The unit meets MIL-STD-202C specifications.

Electrical specifications include: insulation resistance, 500v dc, 500 megohms minimum; dielectric strength, 500v, 60 cycles; capacitance, less than 50 mmf at 1 mc; contact resistance variations (noise), less than 15 milliohms peak to peak. The unit withstands shock of 30 g's, vibration of 10 to 2,000 cps, 0.25 in. double amplitude and 95% relative humidity (non-operating). Operating temperature range is 0 to 85°C.

Circle No. 168 on Subscriber Service Card

Dilatometer

A series of transistorized, automatic Linseis dilatometers is being marketed by William J. Hacker & Co., Inc.

The horizontal vacuum model has a temperature range of —40° to 2,200°C. The vertical cryogenic model has a range of —40° to 70°C. The measuring systems are available in quartz, alumina and tungsten. Sample sizes range from 1 to 13 mm in diameter and up to 100

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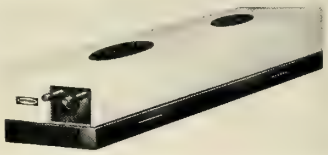
mm in length. Amplifiers are available to 50,000x and can be equipped with electronic compensation for expansion of alumina measuring systems.

Circle No. 169 on Subscriber Service Card

Argon Laser

A continuous-wave argon laser operating in the single transverse mode (TEM_{00}) is available from Raytheon Co.'s Laser Advanced Development Center.

The Model LG12 has 1-watt power output over a range of 4,545 to 5,145



Angstroms in the blue-green portion of the visible spectrum. Principal lines are at 4,880 and 5,145 Angstroms. The water-cooled laser head measures 40 x 12 x 10 in. and weigh less than 100 lbs. Power supply inputs are 208/120v, 60 cps, 50 amperes maximum.

Circle No. 170 on Subscriber Service Card

Emissivity Instrument

A total hemispherical emissivity instrument capable of measuring solids at temperatures from −200° to 2,500° F is being manufactured by Dynatech Corp.

In order to obtain data, two samples 2.5 in. sq. and up to 0.05 in. thick are attached to an electrical sample heater, or a sample coating may be applied directly to the heater. Total hemispherical emissivity is obtained by nulling out the conductive and convective modes of heat transfer and allowing the radiative mode alone to dissipate the measured electrical energy supplied to the heater.

Accuracies range from ±0.1 for the −200° to −100° F range and ±0.02 for the 500° to 2,500° F range. A vacuum of 10^{-4} mm Hg can be obtained with a 4-in. diffusion pump and mechanical forepump in the standard −4v instrument under cold, clean conditions.

Circle No. 171 on Subscriber Service Card

Coherent Information Adder

A data processing instrument which reinforces and clarifies relevant data in any repetitive information system has been developed by Block Engineering, Inc.

The Coherent Information Adder, or "Coadder," intensifies signal-to-noise ratio and minimizes random anomalies with the repetitive signal. A variety of output formats is available. Stored information can be digitally recorded on magnetic or punched paper tape or transferred directly to a computer. Alternately, information can be read out repetitively as an analog signal on an oscilloscope or chart recorder.

The device has a standard core memory capacity of 1,024 words at 16 bits with optional provision for up to 32,000 words. Sampling input frequency is 250 cps to 30 kc. Input digitization accuracy is 0.5%; analog output is 0.025%.

Circle No. 172 on Subscriber Service Card

Multiphase Amplifier

A multiphase amplifier designed specifically for gyro applications is being marketed by International Electronic Research Corp.

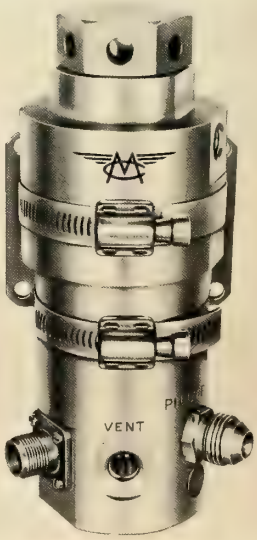
The model MA-2100 consists of dual 50-va amplifiers, using a separate dc-referenced voltage stabilizing circuitry for each channel. Phasing between amplifiers is automatically held to 0.1-degree accuracy over a frequency range of 200 to 800 cps. The unit can be used with either two- or three-phase gyros.

Circle No. 173 on Subscriber Service Card

Moisture Separator

A moisture separator specifically designed for 3,000-psi pneumatic systems is being marketed by M. C. Manufacturing Co.

The MC 8351 operates in an ambient temperature range of −65° to 180° F. It contains a thermostatically controlled, 28-v dc heating unit to prevent freezing of stored water. A burst-disc safeguards the pneumatic system; it will release at 5,700 to 6,700 psi.



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Lewis W. Douglas, Jr.: Elected to the board of directors of Mesa Scientific Corp., Inglewood, Calif. He is president of the Christiana Oil Corp.

Howard E. Orem: Elected chairman of the board of Valley Metallurgical Processing Co., Inc., Essex, Conn. The company specializes in finely powdered metals, used particularly in the liquid propellant utilized by *Titan III*. He is a retired Vice Admiral of the U.S. Navy.

Dallas Talley: Named marketing director of United Gas Corp., Santa Ana, Calif., subsidiary Benson-Lehner. The company is active in the data handling and digital plotting fields.

Lockheed Missiles and Space Co., Sunnyvale, Calif., has announced program managers for its team bidding for the *Manned Orbiting Laboratory* project. They are **Charles B. Wilson,** for Lockheed; **K. K. Miller,** Radio Corp. of America; **David Franks,** General Precision, Inc.; and **Richard A. Fischer,** for the AiResearch Division of the Garrett Corp. If successful in the Air Force bid, Lockheed would have overall industry program management.

Dr. Charles G. Merckel: Elected National Surgeon of the U.S. Naval Reserve Association. He is medical director of the western operations of Sylvania Electric Products, Inc., New York City. **Haig J. Shalvarjian,** also of Sylvania, was appointed manager of contract negotiation and administration for the western operation.

Martin S. Schletter: Elected vice president of Tenney Engineering, Inc., Union, N.J. He will continue in charge of sales and engineering of the Environmental Div.

Roland P. Carlson: Promoted to general manager, space exploration group, Martin Co., Baltimore. Also promoted was **Don P. Herron,** who will become assistant to the president.

Donald G. Thomson: Appointed vice president and staff assistant to the president of ITT General Controls Inc., Glendale, Calif.

Paul G. Hansel: Promoted to vice president-engineering, Electronic Communications, Inc., St. Petersburg, Fla. Also promoted within ECI were **Robert G. Walker,** vice president-systems requirements; **Morton S. Klein,** divisional vice president-program management; **Frank W. Furda,** divisional vice president-controller; and **Joseph R. Mensch,** manager of systems engineering.

Harold P. Henderson: Elected president of Clover Industries, Inc., Tonawanda, N.Y. He was also elected a director of Glass-Tite Industries, Inc., Meadville, Pa., which recently acquired Clover.

John D. Heasley: Assumed responsibility for Westinghouse Electric Corp.'s Westing-Arc Div. in Baltimore.

Kenneth I. Pressman: Appointed manager, operations control, Radio Corp. of America's Aerospace Systems Div., Burlington, Mass. He was formerly manager of program administration control of RCA's Missile and Surface Radar Div.

Clarence J. Woodard: Elected to the board of directors of Systron-Donner Corp., of Concord, Calif. He is also president and director of the Rucker Co., a subsidiary of Systron-Donner.

Dr. James C. Keck: Appointed a Ford Professor of Engineering at the Massachusetts Institute of Technology, Cambridge, Mass. He will establish a laboratory for atomic and molecular kinetics at MIT.

Ralph H. Ruud: Appointed corporate vice president-manufacturing of North American Aviation, Inc., El Segundo, Calif. He was formerly president of the Los Angeles Div. **W. E. Swanson,** who has been serving as executive vice president at Los Angeles, has been named to succeed Ruud. **E. N. Ljunggren,** vice president of *Minuteman* systems management at the Autonetics Div., takes over Swanson's former post.

Jack P. Rogan: Promoted to vice president-director of operations at Douglas Aircraft Co.'s Space Systems Center, Huntington Beach, Calif. Named to succeed him as vice president-general manager of the company's Tulsa Div. was **O. L. Howser.**

J. B. Montgomery: Elected president and chief executive officer of the Marquardt Corp., Van Nuys, Calif. He was also elected a director. He was formerly with a Schlumberger, Ltd., subsidiary, Weston Instruments, Inc. **Roy Marquardt,** whom Montgomery succeeds, became chairman of the board.

William D. Owens: Named divisional vice president of Honeywell Inc.'s Denver Div. in Denver, Colo.

Dr. Edgar Eichhorn: Named director of operations for the central region of C-E-I-R, Inc., Washington, D.C. He will have responsibility for both the professional services and computer operations staffs for the company.

Daniel J. Crowley: Appointed director of engineering for the eastern operation of Sylvania Electric Products, Inc., Waltham, Mass.

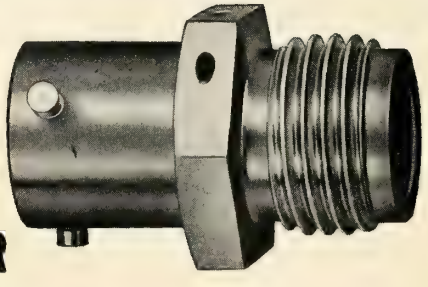
Samuel J. Davy: Elected president of Epsco, Inc., Westwood, Mass. He has been a director of the company since July, when he was appointed general manager and chief operating officer of the company.

A. R. Wilde: Appointed manager of systems programming services for Sperry Rand Corp.'s UNIVAC Div., New York City. **H. A. Richard Wegener,** a solid-state physicist, has joined the scientific staff at the Sperry Rand Research Center in Sudbury, Mass.

Arthur J. Hatch: Named president of the G. T. Schjeldahl Co., Northfield, Minn. He has been executive vice president of the company since last June.

Dr. Albert Muller: Elected a vice president of Air Reduction Co., Inc., New York City. He will be responsible for the corporation's science and engineering programs.

Richard P. Klopp: Named executive vice president of Catalytic Construction Co., Philadelphia. He is also a director of the company.



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—when and where—

DECEMBER

Symposium on High-Energy Astronomy, sponsored by Air Force Office of Scientific Research, Atomic Energy Commission, NADA, National Science Foundation, Office of Naval Research and the University of Texas, University of Texas, Austin, Dec. 15-18.

131st Annual Meeting, American Association for the Advancement of Science, Montreal, Canada, Dec. 26-31.

JANUARY

Eleventh National Symposium on Reliability and Quality Control, sponsored by the American Society for Quality Control and the Institute of Electrical and Electronics Engineers, Fountainebleau Hotel, Miami Beach, Jan. 12-14.

1965 Government-Industry Forum, sponsored by the National Electrical Manufacturers Assn., New Orleans, La., Jan. 18-19.

International Symposium on Solar Radiation, sponsored by the American Society for Testing and Materials and the Institute of Environmental Sciences, International Hotel, Los Angeles, Jan. 18-21.

Winter Meeting of the National Society of Professional Engineers, Jung Hotel, New Orleans, Jan. 20-23.

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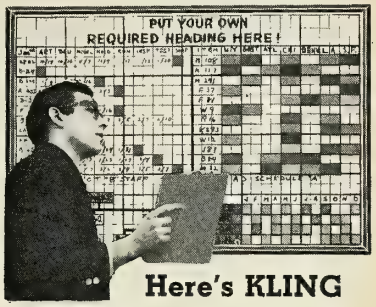
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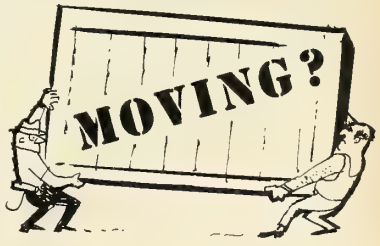
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The MOL Decision

THE NEED FOR the Air Force *Manned Orbiting Laboratory* program is so strong that we fail to see how it could be questioned.

MOL was not initiated as a program for operational military hardware; it was designed to find out what the Air Force can do in space. Perhaps no one of the experiments planned for *MOL* is of vital national importance in itself. Added together, however, they become a package that calls for action.

It is, as Secretary of Defense Robert McNamara himself has pointed out, a project for developing "the techniques which would be required were we to ever suddenly be confronted with a military mission in space."

You can be sure that when the confrontation comes, it will be sudden. We must act on the assumption that a military capability in space will be needed. If history proves that it is not, so much the better. To state what should be obvious, it is better to have it and not need it, than to need it and not have it.

That is the compelling reason why the alternatives which have been proposed for *MOL* make so little sense. An important year has been lost between the cancellation of *Dyna-Soar* and the initiation of *MOL*. It is impertative that no more time be lost.

Use of *Apollo-X* in place of *MOL* means a delay of at least two years in ascertaining the operational need for a manned military space capability, to say nothing of how many more years it would take to achieve that capability.

We do not question the fact that looking two years down the road may find a better approach to the job that *MOL* is intended to do. Two years from now, another look down the same road will find an even better method of accomplishing it four years hence. Anyone who has ever designed a missile, airplane or spacecraft knows that a cut-off date is a necessity. At some point, the project must be frozen and a go-ahead given despite the improvements that may lie just days or weeks ahead. If that is not done, the hardware will never be built. Design can continue forever if the decision is not made to forego the promised improvements and save them for the next model.

The military space program is at that point. It is time to start work.

Certainly, the very active manned flight program of the National Aeronautics and Space Administration is moving ahead at a good pace. But this is not a military program and, by its very nature, is not designed to accomplish military objectives. Fallout there may be, but the Air Force has objectives of its own to reach. Only the Air Force can reach them.

Down that road may lie an effective missile defense, vastly improved reconnaissance capabilities and perhaps a devastating offense. Only the Air Force will find out. NASA will not because NASA will not be looking.

A needle in a haystack is a pretty difficult thing to locate. You can find it, however, if it is there and if you take enough time and trouble in the search. You won't ever find it if you don't look and you may be surprised to discover that some other fellow has located it and is sticking it in your backside.

For more years than we care to count, we have been preaching the need for an effective military space program. The nation still does not have one. Even in so clear an area as communications, the problem has been studied, re-studied, defined, redefined, viewed and reviewed so long that civilians around the globe will have been chattering away at each other for years via communications satellites before military officers in Viet Nam solve the problem of getting a message back to the Pentagon.

DR. HAROLD W. RITCHEY, the forthright and incisive president of Thiokol Chemical Corp., had some pertinent things to say about this state of affairs in a speech at this month's American Ordnance Assn. meeting in New York:

"There are too many instances in history when authority has thought there was enough. Not more than thirty years ago, cavalry generals were saying that enough horses were better than tanks and battleship admirals were saying that we had enough battleships to deter an aggressor . . .

"Less than fifteen years ago, some of our most renowned scientists advised us that the ICBM was impossible and that effort and resources should not be wasted in developing it . . .

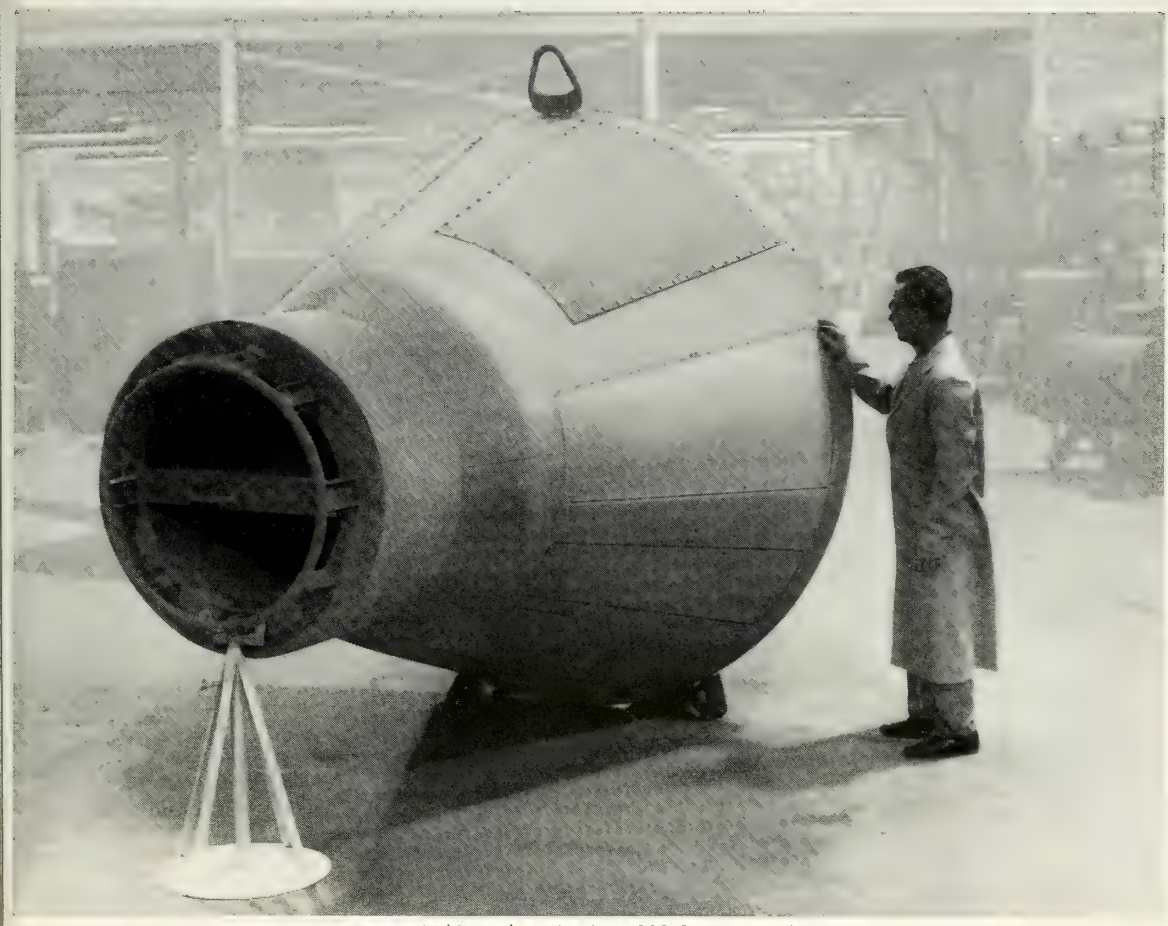
"Suppose we could transport instantly a group of today's renowned scientists into the future by a distance of fifteen years. Is there any reason to believe that they, too, would not be thoroughly confused by the machines, devices and technologies which they would encounter? And, would they be more confused here, or in Russia?"

Dr. Ritchey points out that the evolution of major high-risk weapon systems was largely responsible for the momentum behind the scientific and technological advances in this country during the last fifteen years —not direct funding for these purposes. That momentum now is gone. As he says, it is not that technology has leveled off, but rather our own actions which are responsible.

The Thiokol president asks whether this same phenomenon is also taking place in the Soviet Union. If the answer is no, he says, if they are pursuing improvements and advances in their defense posture as well as in their scientific and technological capability, then our slowdown can only lead to their catching up and surpassing us.

We agree wholeheartedly. The decision on *MOL*, and the entire military space program, is a critical one.

William J. Coughlin



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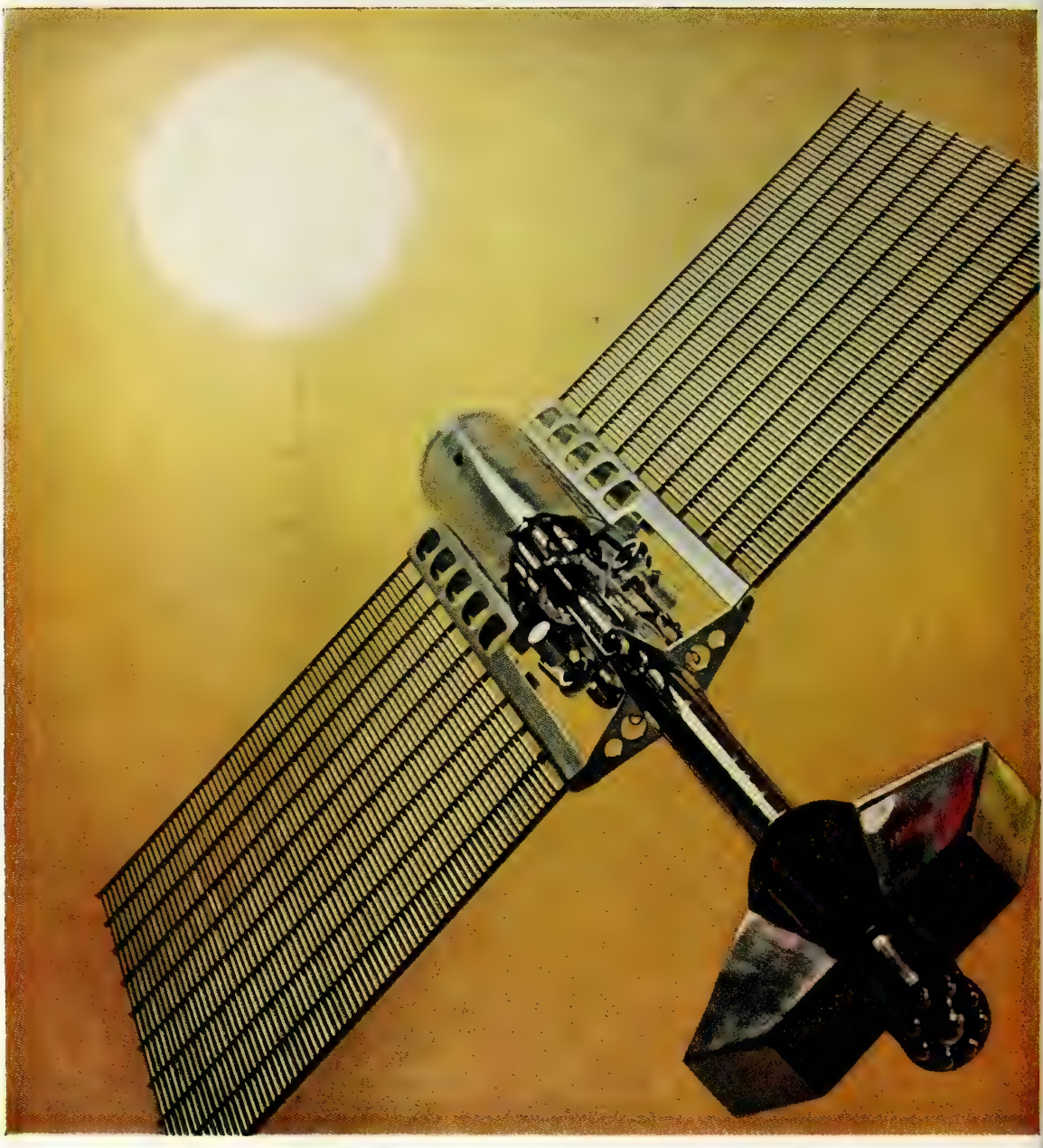
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missiles and rockets

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MOL Gets Full-Scale Development Okay

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AES Manned Lunar Orbit Plans Listed . . .

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Published each Monday with the exception of the last Monday in December by American Aviation Publications, Inc., 1001 Vermont Ave., N.W., Washington, D.C. 20005. Cable Address: AMERAV.

Printed at Judd & Detweiler, Inc., Washington, D.C. Second class postage paid at Washington, D.C.
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Subscription rates: U.S. and Possessions, Canada, and Pan American Postal Union Nations: 1 year, $5.00, 2 years $8.00, 3 years $10.00. All other foreign: 1 year $15.00, 2 years $25.00, 3 years $35.00. Air freight to Europe: 1 year $20.00, 2 years $30.00, 3 years $40.00. Single copy prices: regular issues 50 cents each; special issues $1.00 each. Subscriptions are solicited only from persons with identifiable commercial or professional interests in the missile/space industry. Subscription orders and changes of address should be referred to Circulation Fulfillment Mgr., Missiles and Rockets, 1001 Vermont Ave., N.W., Washington, D.C. 20005. Allow 4 weeks for change to become effective and enclose recent address label if possible.

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THE COVER



Navy's new solid rocket propellant torpedo, Mk 46-0, shown on drone helicopter in sea test. Weapon can be launched from helicopter, fixed-wing aircraft, surface ship or ASROC launcher. Developed by NOTS and Aerojet-General, prime contractor, it will be operational next summer. See p. 15.

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M/R does not publish an issue on the last Monday in December. Readers are reminded that there will be no issue on Dec. 28.

Season's Greetings—The Editors

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letters

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Done.—Ed.

Civil Service Invitation

To the Editor:

Refer Mr. Henry Albert's letter on Civil Service management in your Dec. 7 issue.

Mr. Albert is cordially invited to visit this activity—as is any other individual holding similar views.

J. Gordon Vaeth, Manager
TOS Systems Engineering Div.
National Weather Satellite Center
Washington, D.C.

Go, Tiger!

To the Editor:

In your Nov. 16 issue an article entitled "Fund Limitations Force *Voyager* Mars Mission Delay Until 1971" (p. 12) contained a discussion concerning "a worthwhile Mars fly-by mission. . . ." "Instrumentation for this mission would probably be that proposed for the 1966 mission by a special 'tiger team' of *young, dynamic* scientists at the Jet Propulsion Laboratory" (italics the writer's).

Will you please elaborate upon the characteristics of a "tiger team?" Also, what does a young, dynamic scientist do? Does that mean that he studies dynamic rather than static problems? How does he differ from older scientists—with respect to agility? Or has your author been brainwashed by JPL's instrumentation group?

H. R. Maleski
Las Cruces, N.M.

Six-Month Index

AN EDITORIAL INDEX of the articles appearing in MISSILES AND ROCKETS during the last six months of 1964 is available to subscribers free of charge.

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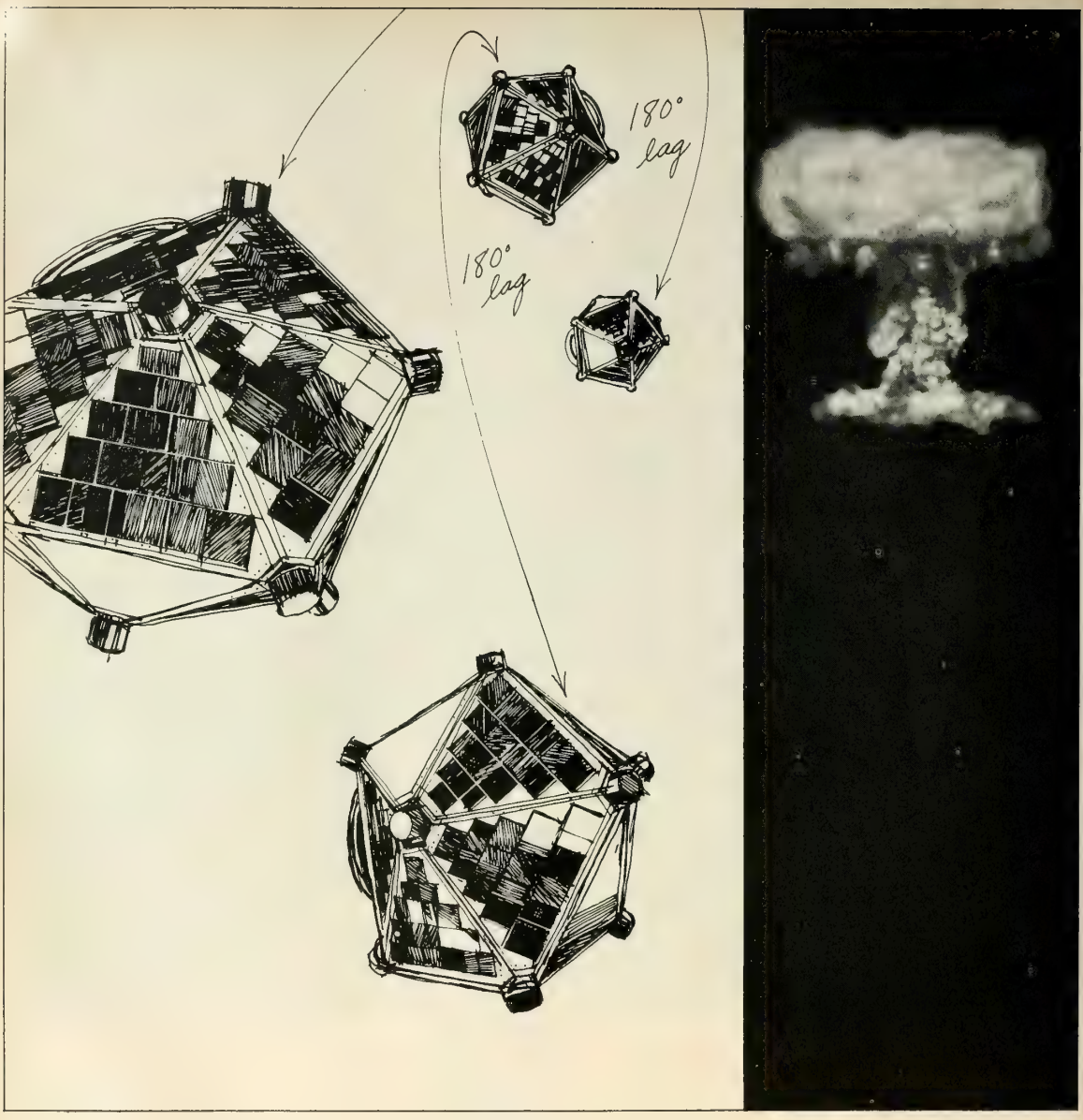
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The Countdown

WASHINGTON

New Upper Stage Work Moves Along

NASA's Office of Space Sciences & Applications now expects to go into program definition of a 7,000-lb.-thrust high-energy upper stage engine in Fiscal Year 1966, with hardware funding in the FY '67 budget. In the meantime, it is continuing in-house studies at Lewis Research Center with FY '65 money.

Feasibility Check of Mauler Continuing

Feasibility validation program for the Army's *Mauler* air-defense system now is not expected to be completed until February. Previously, Army officials have used this date as the target for resumption of the development program. Now it will be May or June before results from the validation program have been digested and the Army is able to recommend action on the program.

Air Force Looks Beyond START

Two lifting-body re-entry configurations are being considered in an Air Force program called "Re-entry Aerodynamic Maneuvering Program." Pentagon AF officials say these are study efforts aimed at something beyond the START program. RFP's from Wright-Patterson, however, call for use of unmanned drone, subscale models dropped from the *X-15* and other aircraft to economically investigate supersonic through subsonic regions of glide re-entry. One of the models is described as using "variable geometry to allow conventional horizontal landings."

Radio Astronomy Satellite Marks Time

NASA Associate Administrator Robert C. Seamans will make no decision on the *Radio Astronomy Explorer* satellite program until he gets more definitive information as to the size of the agency's FY '66 budget request. Program approval document for the project has been on his desk for several weeks; because of his new ground rules, it is expected to remain there for several more at least.

Nike-Hercules Given ATBM Capability

In what must be the most-unintended announcement of the year, the Army revealed that the *Nike-Hercules* has undergone "extensive modifications . . . to give the system anti-tactical ballistic missile (ATBM) capabilities." At the heart of the new system are two radars: a high-power acquisition radar (HIPAR) and a low-power acquisition radar (LOPAR). This probably is a mobility package approved in FY '62 to increase *Nike-Hercules* capability for field army air defense operations.

NASA Taking Long Look at Ocean Platforms

Twenty-four firms have been asked by the space agency to study feasibility of using stable ocean platforms as bases for tracking stations for some of its sounding rocket programs. Proposals are due at the Goddard Space Flight Center by Dec. 8, 1965.

On Key, But Out of Pitch

U.S.-German cooperation on development of the Main Battle Tank is running smoothly except for a problem in pitch. So serious is this, however, that it is to be decided at the Von Hassel-McNamara level. It seems that the pitch used on fasteners in the two nations differs. A U.S. bolt of the same dimensions will not screw into a German nut more than a couple of threads because of the different pitch of the threads. Which country will have to change is a big problem.

Pound-Foolish Mars Economy?

House Space Committee members are voicing concern over the NASA decision to eliminate a Mars probe during the 1969 opportunity to impact that planet. Subcommittee chairman Joseph E. Karth (D-Minn.) said his group will take a close look at this decision, on the basis that all possible scientific information should be obtained in case a decision is made for a manned Mars mission. Biosciences program offices are pushing for at least a *Voyager* vehicle test, to prepare for a 1971 assault.

INDUSTRY

New Team Seeks Voyager Study Contract

COUNTDOWN has learned that TRW Space Technology Laboratories, Eastman Kodak, and Douglas Aircraft's Missile & Space Systems Div. have formed a team to compete for a *Voyager* program design study contract to meet NASA's objectives for unmanned exploration of Mars in the next decade. STL will be prime contractor for the team, with responsibility for mission analysis, electronic subsystems, propulsion integration and system integration and test. DAC will be responsible for major spacecraft structure and interstaging and for mechanical aerospace ground equipment. Eastman will be in charge of the Mars imaging subsystem and ground imaging reconstitution system. Other prospective teams are Lockheed and RCA; GE, Texas Instruments; Boeing, Philco and Electro-Optical Systems; Avco and Honeywell. Other contenders will be Hughes, Northrop and Martin—probably with other team members. Total program is likely to cost $1 billion.

INTERNATIONAL

French Plan NOTS-Type Test Track

The French government is planning to erect a test track similar to one at the Naval Ordnance Test Center, China Lake, Calif. Maj. Jacques Bergez of the French Ministry of Defense said during a tour of NOTS facilities that France's space vehicle test center located in French Guiana is "a bit far away from home base." He said a new R&D test center for which he is gathering test-track data "is being rushed to completion as soon as possible."

Sea Dart Nose Dampened in Desert

Hawker Siddeley Ltd. is testing the effect of rain erosion on the dielectric nose cone of its *Sea Dart* missile, intended for the Royal Navy. Tests are under way on the 35,000-ft. rocket-sled track at the Air Force Missile Development Center, Holloman AFB, N.M. In spite of ready home access to the natural product, Hawker Siddeley finds it costs less to use the simulated 10-mi. rainstorm at the desert track.

Walleye Award Due Soon

The Navy Bureau of Weapons is preparing to negotiate Program Definition Phase contracts for development of the *Walleye* guided bomb with the Martin Co., North American Aviation and Hughes Aircraft.

Three months after completion of program definition two production contracts will be awarded and a third will be made for additional development of the television-guided weapon.

Naval Ordnance Test Station, China Lake, Calif., is present prime contractor on *Walleye*.

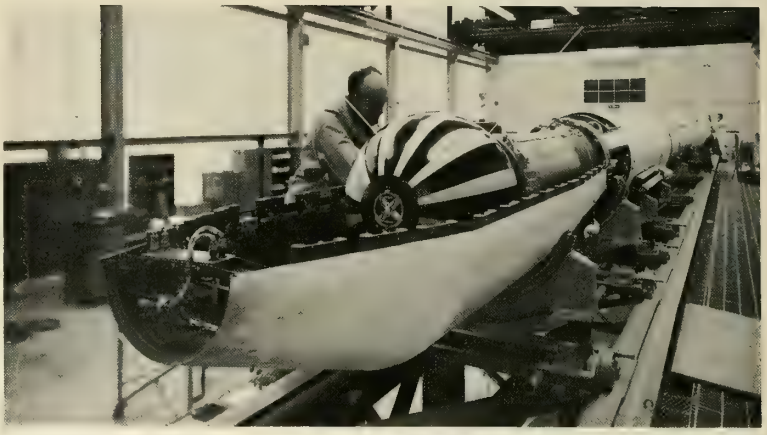
Shots of the Week

An all-Italian crew successfully launched Italy's *San Marco I* satellite from Wallops Island, Va., Dec. 15. The launch, employing a NASA-supplied *Scout* booster, marked Italy's entry into the international space club and was the first time in the NASA international cooperative program that a satellite launch was conducted by a team of foreign nationals.

Apogee is 510 mi.; perigee, 128 mi.; period, 95 min.; and inclination to the Equator, 38 degrees. Apogee is some 90 mi. greater than had been expected (M/R, Dec. 7, p. 10), but perigee was close enough to the intended 135 mi. to accomplish the key objective, conduct of an atmospheric drag experiment.

Because of the low perigee, the satellite is expected to have a lifetime of only a few weeks.

- The Air Force achieved the first success in two launches of its *Titan III-A* booster Dec. 10 from Cape Kennedy. The restartable transtage went into orbit carrying a 3,360-lb. inert payload, which it injected into 100-mi. orbit.
- Air Force Captain Joseph Engle flew the NASA-Air Force *X-15* rocket plane from Edwards AFB, Calif., Dec. 10 on a mission to study aerodynamic heating. Top speed reached was 3,580 mph and maximum altitude was 112,000 ft.
- The Soviet news agency Tass announced Dec. 10 that the Soviet Union has launched *Cosmos 51*, the latest in a series of scientific satellites.
- Despite failure of the engine to restart, NASA's launch of a *Centaur* stage Dec. 11 was said to have met all test objectives. Launch vehicles was an *Atlas*. (See p. 14.)



SAN MARCO satellite being checked out with Scout vehicle before launch Dec. 15. See "Shots of the Week" at left.

- An Air Force crew successfully launched a *Minuteman II* from Cape Kennedy on Dec. 15. Shot traveled some 5,000 mi. down the Eastern Test Range and impacted on target.
- NASA used *Nike-Cajun* and *Aerobee* rockets to launch two experiments from White Sands Missile Range Dec. 16. The experiments were to measure cosmic dust and electron densities in the upper atmosphere.

ComSat Sale Stopped Again

A 100% margin requirement for all purchases of Communications Satellite Corp. stock was initiated last week in an attempt to discourage speculation and stabilize the stock's volatile situation.

The Board of Governors of the New York Stock Exchange acted after the stock, the exchange's most active commodity for over a week, reached a new high of $70.75 on Dec. 14 and then dropped $10.50 the following day. Usual margin requirement for stock purchases is 70%.

Some brokers attributed the stock activity primarily to short sales and covering of short sales. Many dealers were warning prospective short sellers in ComSat of the danger of such trades.

The Exchange estimated the short interest in stock as of Dec. 9 at 300,000 shares, up from 69,888 shares on Nov. 13. The report on Dec. 15 came three days before normally due. President Keith Funston said that the Exchange would continue a close watch on the situation.

Central Audit Agency for DOD

Secretary of Defense McNamara has announced that the Dept. of Defense is creating a department-wide Defense Contract Audit Agency to more efficiently audit defense contracts.

The new agency, to be headed by a director of two-star grade, will consolidate the activities now performed by 3,600 personnel in contract auditing units existing within various military departments. The agency director will report to the Assistant Secretary of Defense (Comptroller).

In addition to improved efficiency, the new group is expected to make possible a 5% saving in overhead costs through reduction of manpower requirements. Some 180 jobs are expected to be eliminated through attrition at an annual saving of $1.8 million.

Weather Bureau Seeks Buoys

Data collection buoys for the Weather Bureau satellite system will be procured in the near future by the National Weather Satellite Center.

NWSC is seeking sources for services and material for advanced development models of "water-borne automatic unmanned weather stations" by January 14. Companies with mooring and static meteorological sensor technology and design capabilities are being sought.

The Weather Bureau has estimated that operational ocean coverage could be obtained with

sensor-bearing buoys moored in a world-wide grid of about 180 miles point-to-point. Barely operational coverage could be provided with points located as far apart as 800 miles (M/R, Nov. 30, p. 160).

Astronaut Candidates File

More than 900 scientists have indicated an interest in the NASA plan to send scientist-astronauts along on future manned space flights since the recruiting program opened in mid-October.

Deadline for applications is Dec. 31. The National Academy of Sciences will review all applications sometime next spring and make recommendations. The space agency will then select 10 to 20 scientist-astronauts to begin training.

ERC Planning Pact Awarded

Three firms have jointly received the master planning contract for NASA's $60 million Electronics Research Center to be located on a 29 acre site at Kendall Square, Cambridge, Mass.

The U.S. Army Corps of Engineers awarded the contract to the joint venture firms of Edward Durell Stone, New York City; Giffels and Rossetti, Detroit; and Charles A. Maguire Associates, Boston-Providence.

They are to make site utilization studies, synthesis of functional operations, preliminary layout, definition of architecture and materials of construction, conceptual drawings, cost estimates, and a model of the complex. These must be delivered in 24 weeks.

The Center is to have an engineering and administration building, and 10 laboratories devoted to the investigation of advanced electronic systems for space. Construction is to be spanned over five Fiscal Years beginning in FY 1965.

Engineer Academy Approved

The National Academy of Engineering, to be operated on a parallel and cooperative basis with the National Academy of Sciences, has been approved by the NAS.

Dr. Augustus B. Kinzel, vice president-research of Union Carbide Corp., was elected president of the academy at an organizational meeting Dec. 10. Other officers chosen include: Dr. Eric A. Walker, president of Pennsylvania State University; Dr. Harold Work, New York University; and Dr. Thomas C. Kavanagh, Praeger-Kavanagh-Waterbury, Engineers-Architects. By-laws were also adopted at the meeting.

Next step for the new academy is expansion of membership rolls from the founding Committee of Twenty-five, appointed by NAS last March, to approximately 100 members during 1965. Ultimate membership goal is 200 to 300. It is expected that the new organization will be located in the NAS building in Washington.

NAE will share in the responsibility given the National Academy of Sciences in 1863 to advise the Federal Government, upon request, in all areas of science and engineering.

The Articles of Organization of the NAE provide for establishment of a Joint Board of representatives to recommend methods of accomplishing effective cooperation between the two academies.

ESRO Makes Satellite Pact

Hawker Siddley Dynamics and its French partner, Engins Matra, have been selected by the European Space Research Organization to build the first ESRO satellite.

The contract is worth some $2.8 million and will cover four models.

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U.S. NAVY
POLARIS

And now the Pacific...

The Navy's new A-3 Polaris missile, which joined the Atlantic fleet in September, will be on patrol in the Pacific this month. Launched from the depths of the world's largest ocean, the A-3 can hurl its powerful payload 2,500 nautical miles. The A-3 has double the range of the original A-1 that became operational four years ago. No obsolescence here, for either submarine or missile. This was part of the plan from the beginning. When the presently authorized 41 Polaris submarines are completed in 1967, each will be capable of handling each one of the missiles available, be it the 1,500-mile A-2, the A-3, or even the still mightier B-3, now being studied by the Navy's Polaris team. Lockheed Missiles & Space Company, Sunnyvale, California: A Group Division of Lockheed Aircraft Corporation. **Lockheed**



MOL Wins Development Okay

RFP's for program definition due to go out next month; development contractor may be picked by fall; first-year cost estimate tops $150 million

by James Trainor

THE DEFENSE DEPT'S experimental orbiting laboratory to determine the military effectiveness of man-in-space has been approved for full-scale development.

A little more than a year after the *Manned Orbiting Laboratory* (*MOL*) program was announced as a replacement for the cancelled *Dyna-Soar* by Secretary of Defense Robert S. McNamara, it has received the full blessing of the Administration.

Funding of *MOL* in the Fiscal Year 1966 budget will not be revealed until the President's budget is submitted to Congress. However, the first-year development effort has been estimated to be in excess of $150 million.

Defense and Administration officials confirmed that the program had been given the green light and that McNamara's statement in support of *MOL* on Dec. 12 constituted the only public announcement that will be made on the *MOL* approval until January. At that time, in his statement to Congress, he is expected to say more on the subject.

The announcement came in response to a news conference question: "Could you say, specifically, whether you are backing the *MOL* or not?"

"Yes, indeed," was McNamara's reply. He went on to emphasize the necessity for close cooperation and cross-feed between the Air Force *MOL* and NASA's *Apollo* so that "the Air Force, when it establishes the *MOL*, takes account of what NASA is required to do as part of the *Apollo* program that in turn is directly related to the Lunar Program. And, in turn, I want to be certain that NASA, to the extent that it expands *Apollo* beyond the limits required for the Lunar Program, takes account of whatever we must do in the *MOL* to meet *bona fide* military objectives."

In answer to a previous question, the Secretary emphasized strongly that duplicate space programs should be avoided and that the great bulk of expenditures should rest in NASA "because the bulk of the National Space Program will be oriented toward civilian scientific and other objectives."

"There is a place, there is a requirement, for a military component," he said. "We must maintain security, a high level of security, on certain elements of the space program and that portion of the program must be handled by the Defense Department."

● **Reports of death exaggerated**—The Administration decision to go ahead with *MOL* as a separate program and not to wait to include it in an *Extended Apollo* spacecraft should put to rest the completely false published reports to the contrary. These have persistently asserted that *MOL* would be cancelled.

There had been opposition to *MOL* by members of the Administration and particularly from the President's Science Adviser, Dr. Donald Hornig. He believes, as do some members of the President's Scientific Advisory Committee, that *MOL* duplicates *Apollo-X* without having sufficient size or capability to represent a forward step in space exploration.

Defense officials have successfully overcome this argument—pointing out that *MOL* will give the Air Force a capability to conduct important military experiments in space. While *Apollo-X* could be used for some of these, it could not be used for all, they assert. In addition, use of Apollo-X would further delay Defense efforts to determine the usefulness of man in military space systems. *MOL* is expected to fly two years before the *Apollo-X*.

● **Industry competition next**—During the past year, the *MOL* concept has been refined and polished—in-house at Space Systems Div. of the Air Force Systems Command and through study contracts of various subsystems that would be required in a *MOL*. Three principal studies—by Douglas, General Electric and Martin—have now been completed. These covered the *Orbiting Space Station* and were "a significant first step" in defining *MOL*.

Specifically, the *OSS* studies defined man's "military charter in space," the systems needed to fulfill that charter and the development efforts required to obtain those systems. Testing requirements for *MOL* equipment were also to be outlined.

Concurrently with the *OSS* studies, SSD has awarded over a dozen parametric studies of *MOL* subsystems, including the enviromental control, attitude control and electrical subsystems. These were fixed-price, level-of-effort contracts which ran for 105 days and are expected to provide the factual basis for selection of specific subsystems. Also, SSD awarded contracts to the Martin Co. and McDonnell Aircraft Co. to determine what modifications are required to the *Titan III-C* and the *Gemini* spacecraft to adapt them to the *MOL* mission.

● **Tentative timetable**—Now that all of these inputs have been digested, SSD is expected to issue Requests for Proposals to industry for the Program Definition Phase of *MOL* in January. With the intensive industry interest in *MOL* and preparation for the program, it is expected that proposals could be received by SSD in 60 days.

Evaluation and selection of the Program Definition contractors could be made 30 days later. PDP is expected to take about six months, which would mean that the final selection of a development contractor would be made by



BOEING ARTIST'S concept of MOL and launch sequence.

the fall of 1965. This schedule, officials point out, is extremely tight; the whole process may take longer to accomplish.

Once the development contract is awarded, the first full *MOL* flight is expected within 27-30 months. This would mean the first flight would take place in 1968. Secretary McNamara a year ago placed the first unmanned *MOL* flight in late 1967, with the first manned flight in the first half of 1968. At that time, he also said that unmanned *Gemini* launches would take place "in the first half of 1966, and manned in the second half of '66, and the laboratory launches associated with *Gemni X* roughly a year later."

Cost of development of *MOL* and a flight program of six *MOL* launches has been estimated at over $1 billion.

Meanwhile, industry has been conducting extensive company-sponsored work on *MOL* and most of the contractor teams have been formed in anticipation of the program. Contractors known to be interested in bidding on the program include: Lockheed Missiles and Space Co. as team leader of RCA for telemetry, tracking, communications and data management subsystems; General Precision, Inc., navigation and guidance system; and AiResearch Div. of the Garrett Corp., life support and environmental control.

Boeing Co. has teamed with Hughes Aircraft Co. for experiment integration, data processing and display; Philco Corp., telecommunications and Honeywell, Inc., attitude control system. General Dynamics / Astronautics and TRW Space Technology Laboratories form another bid team; as do General Electric and Republic Aviation, Martin and AC Spark Plug, Douglas and IBM. North American Aviation and McDonnell also are expected to bid on the program.

● **MOL as seen now**—Basically, *MOL* remains the same as when McNamara outlined it in December, 1963 —a modified *Gemini* with a small house-trailer-sized laboratory module attached to it.

Considerable refinement of this concept sees it as the modified *Gemini* with a two-compartment, 14-ft.-long, 10-ft.-dia. laboratory. The larger compartment would contain the military experiments, vehicle monitors and any other scientific equipment. Also, the living quarters for the two-man crew would be located in this pressurized section. Forward of this would be another compartment serving as an air lock between the *Gemini B* and the laboratory.

Internal volume of the canister is expected to be about 2,000 cu. ft. Weight of the entire *MOL* is placed at 18-20,000 lbs. with an empty laboratory weight of 8,000 lbs. Launch vehicle for the combination is the *Titan III-C*.

Structure of the laboratory is to be a foam-filled aluminum truss core sandwich with flush-mounted thermal radiators. Access to the laboratory from the *Gemini* is expected to be provided by an exit cut in the *Gemini* heat shield. Electrical power will be provided, at least initially, by adaptation of *Gemini* or *Apollo* fuel cells with possibly isotopic power sources or solar panels for follow-on missions. Spacecraft environment will initially be 100% oxygen, with a mixed-gas atmosphere introduced later. A shirt-sleeve environment is to be provided for the crew for the 30-day-duration missions now planned.

In the area of *Gemini-Laboratory* interfaces, the *Laboratory* will supply its own electrical power, pressure and thermal control as well as any standby *Gemini* requirements while in orbit. Attitude control and stabilization also will be an integral part of the laboratory.

● **To prove man's worth**—*MOL* is still an experimental project to prove or disprove the utility of man in space for military missions. To meet this goal it must fulfill five basic objectives:

—A minimum essential in-space test facility must be provided at an early date.

—The functions to be performed should provide a measure of man's usefulness, and be preceded by aircraft and ground simulation tests.

—Requirements are to be met whereever practicable with equipment currently under development, and the approach selected has to show minimum developmental and operational risks.

—The program schedule must be reasonable and attainable, with a commensurate fiscal commitment.

—There must be a basis for orderly growth—in the event that future needs develop and man's utility is demonstrated.

Among the areas of investigation, one of the foremost is observation. In contrast with the myriad of repetitive, useless data returned from space by observation satellites, a manned observation system may be able to provide the most effective and versatile filter so that only significant information is gathered. Also, man can focus telescopes or other sensors on unusual Earth activities to yield a greater degree of information per unit of time over the target.

Man's value as a repairman for space equipment or as an on-the-scene experimenter is of interest. One possibility that has been suggested is the use of manned space vehicles to fire re-entry models into the atmosphere as part of a more flexible re-entry vehicle test program. Satellite inspection and interception, anti-ICBM potential, meteorological data-gathering, study of weapons effects on space vehicles, and space-based offensive capabilities against ground targets are other areas of potential mission applications.

Most important initially, however, will be the physical limitations of man in space.

Currently, the *MOL* program does not include a requirement for rendezvous, but should the program be extended this would become a requirement. Dr. Harold Brown, Director of Defense Research and Engineering, told Congress earlier this year that the "ultimate capability" of *MOL* included rendezvous, resupply and orbital assembly into a space station. This is not in the present *MOL* program, he emphasized, but it could be "if and after . . . we conclude . . . that a man can have a substantial military purpose" in space. ■

Manned Gemini Shots Top Schedule

Pegasus, Pioneer, Surveyor, OSO, OAO to make initial flights; 1964 launch record was 27 successes in 31 attempts

by Hal Taylor

THE SPACE AGENCY has scheduled a total of 27 launches in 1965, beginning with another attempt to launch the second *Gemini-Titan II* early in January.

Next year's schedule will be only slightly behind the 1964 pace, which saw the agency chalk up 27 successful flights in 31 attempts.

In addition to the unmanned *Gemini* ballistic launch, 1965 will see the return of manned space flights to the U.S. space program. Four manned *Gemini* missions are planned, with the first manned rendezvous slated for late in the year. This, however, will probably slip into 1966.

GT-2 has been re-scheduled by the space agency for the first or second week in January. The first launch attempt was aborted Dec. 9.

The *Titan II* engines had burned for 1.7 seconds before a safety system detected a malfunction and shut down the big booster. Space agency officials reported that the trouble stemmed from a broken servo valve. Late last week, however, they still had not determined what caused the valve to fail.

The flight will be an all-systems suborbital test. The primary objective will be to check out all spacecraft systems and obtain re-entry heating measurements. The *Titan II* launch vehicle will send *Gemini* to an altitude of 105 miles. It will attain a speed of 16,600 mph before plunging into the Atlantic some 2,150 miles downrange from Cape Kennedy.

● **After GT-2**—GT-2 will be followed early in the spring by the first manned *Gemini* flight, which calls for a three-orbit mission. Long-duration flights will be attempted for periods of three days, seven days and two weeks before the first manned rendezvous is attempted late in the year.

Other important 1965 launches include the first three launches of the *Pegasus* meteoroid-detection satellite by the *Saturn I* booster, the first launch of the *Surveyor* engineering model spacecraft with the *Centaur* upper stage, two *Ranger* shots to the Moon, and the first launch of the *Pioneer* solar probe.

The remainder of the schedule calls for three other *Centaur* launches, two *Apollo* abort tests with the *Little Joe II*, the first launch of France's international satellite, two geodetic satellites, another *Tiros* meteorological satellite, an *Orbiting Solar Observatory* (*OSO-B2*), the first launch of the *Orbiting Astronomical Observatory* (*OAO-A*), the U.S.-Canadian *International Satellite for Ionospheric Studies* (*ISIS*) and one *Interplanetary Monitoring Platform* (*IMP-B*) mission.

● **1964 a good year**—NASA's successful launch percentage was the highest in its history in 1964. There were only three complete failures and one partial failure to mar the 31 launch attempts.

Perhaps the greatest disappointment was *Ranger VI*, which impacted on the Moon Feb. 2, but failed to send back to Earth TV pictures of the lunar surface.

The other unsuccessful missions were *Mariner III* on Nov. 5, which failed when its shroud failed to eject, and *Beacon Explorer A*, which failed to go into orbit in a March 19 attempt.

NASA LAUNCH RECORD

Year	Launches	Success	Partial Success	Failure	Per Cent Successful
1959	19	6	6	7	31
1960	21	10	2	9	48
1961	24	15	3	6	62
1962	27	18	5	4	66
1963	15	13	1	1	86
1964	31	27	1	3	87

The one partial failure occurred Oct. 3 when the *IMP-B* spacecraft failed to achieve the optimum orbit. It has, however, sent valuable data back to Earth, including the discovery of a neutral sheet in the Earth's magnetic field. Goddard Space Flight Center engineers believe that the "sheet" may serve as a depository for energetic particles and could be partly responsible for the Van Allen radiation belt and the faint glow in the Midnight Sun.

The satellite also confirmed previous theories that the Earth is sort of a magnetic comet. It wags behind it, on the side away from the Sun, a gigantic tail of invisible magnetic force lines stretching 239,000 miles into space.

● **Chronology of success**—The two major successes for NASA in 1964 were *Ranger VII*, which transmitted more than 4,000 pictures of the lunar surface back to Earth July 31, and *Mariner IV*, which was launched Nov. 28 on what now looks like a successful flight to Mars.

Following a mid-course guidance correction maneuver early this month, scientists at the Jet Propulsion Laboratory predicted that the spacecraft will pass within 5,400 miles of the planet next July 14 to take photos. *Mariner IV* lost track of its guiding star, Canopus, Dec. 8. Scientists were expected to attempt to lock the spacecraft on the star late last week.

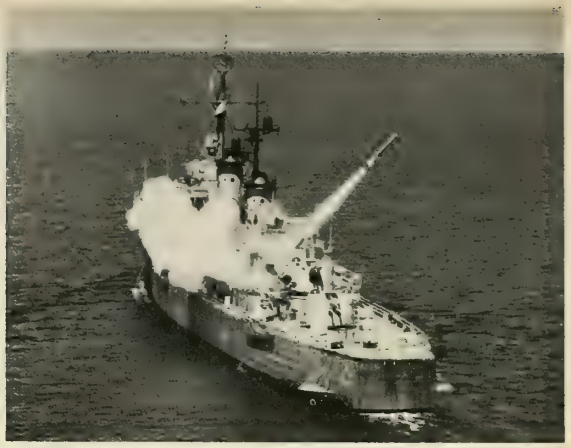
The theory held by NASA scientists is that a reflecting dust particle passed through the field of the spacecraft sensor causing it to lose Canopus.

By overriding the gates on the star sensor, JPL believes that the spacecraft will no longer go into a roll search if a particle enters its field of view.

Another important 1964 mission was the launch of the *Saturn SA-7* booster Jan. 29. It placed the heaviest satellite in history into orbit. This was a dummy *Apollo* spacecraft filled with water, and which weighed 37,400 lbs. ■



NAVY'S SOLID ROCKET propellant torpedo, the Mark 46, Mod 0, heads for its target in open sea operations.



MARK 46 here is used as payload for ASROC ASW torpedo in launch from a destroyer during sea operations test program.

Second version in development . . .

Mark 46 ASW Torpedo To Be Operational Next Summer

INITIAL operational delivery of the Mark 46, Mod 0 anti-submarine torpedo will be made to the fleet "during the summer of 1965," the Navy has announced. Capable of launch from aircraft, helicopters or surface ships, the Mark 46, Mod 0 represents a significant advance in speed, depth performance and maneuverability over the Mark 44 it will replace.

An active acoustic homing torpedo, the Mark 46 can also be fired as a payload for the *ASROC* ASW rocket-boosted torpedo. It falls in the small, lightweight class of torpedoes, according to the Navy, with a weight of approximately 570 lbs. It is 101 in. long and 12¾ in. in diameter. It has a high-explosive warhead.

Navy officials told MISSILES AND ROCKETS earlier this year that the Mark 46, along with the Mark 48 wire-guided torpedo now in development, would be able to cope with the present generation of Soviet nuclear submarines. This includes the ability to seek out the target and elude countermeasures as well as to reach even the deepest diving submersible in operation.

● **Weapon in production**—The Mark 46 was developed by Aerojet-General Corp. and is now in production at the company's Von Karman Center, Azusa, Calif. Operational evaluation of the Mark 46, Mod 0 is currently under way. A second version of the torpedo, the Mod 1, is still under development.

Although no produciton decision has been made on this model, the Navy recently asked for sources competent to produce the Mark 46 without specifying which model. This may indicate the intention of the Navy to choose a second-source contractor for the Mod 1 and produce both versions concurrently.

The primary difference between the Mod 0 and the Mod 1 is in the propulsion system. The Mod 0 uses a solid propellant charge while the Mod 1 has a liquid monopropellant. Advantages of the storable liquid are that it is cheaper and easier to maintain than the solid.

The Mark 46, Mod 0 is the first Navy ASW torpedo to use a solid-rocket-fueled hot-gas propulsion system as its source of power, according to Aerojet. Also, it is the first capable of being launched by fixed-wing aircraft at speeds up to 400 knots. A parachute-retardation device is used to reduce water impact speed.

● **Description**—Basically, the Mark 46 consists of four major components, which, because of their modular construction, can be easily replaced: guidance and control system; explosive system; propulsion system and accessory system. The forebody contains the guidance package consisting of a transducer, a transmitter and receiver, a control group with its power supply, a computer and an autopilot.

The electronics packages are separated by either a "live" or a practice warhead. The center section houses the solid-propellant gas pressure generator, and the afterbody contains the propulsion unit.

After water entry, the propulsion system is activated within one-half second by means of a sea water battery driving the torpedo down to a preset initial search depth. Once there, the torpedo executes a programmed search pattern for the target by active echo ranging or passive listening. Upon locating the target, the Mark 46 starts the pursuit and attack program, closing on and destroying the target. If it loses the target for any reason, the torpedo re-executes the search program to relocate the target.

The first test of this torpedo propulsion system was run in Key West in 1957. The propulsion system was initiated as a cooperative venture in 1956 by the Bureau of Naval Weapons supported by the Naval Ordnance Test Station, Pasadena, Calif., Aerojet and Clevite Corp., Cleveland.

NOTS is program technical director for the Bureau of Weapons and Aerojet is prime contractor. Other members of the team as principal subcontractors to Aerojet are Clevite for the engine and The Bendix Co., North Hollywood, Calif. for the guidance and control system. ■

DOD Considers Further Awards In 156-in. Solid-Rocket Motor Program

Odds on FY '66 funding called at least even; new bid package series to be aimed at development of specific launch systems

by Russell Hawkes

SOURCE SELECTION BOARD recommendations for the next series of 156-in solid rocket contracts have been completed by the Air Force Space Systems Division and are now in the hands of the Dept. of Defense for final disposition. Prospects for Fiscal Year 1966 funding range from "favorable" to "even money," say industry and SSD officials queried by MISSILES AND ROCKETS.

Decisions on the next series of contracts—covering Bid Packages 13, 14, 15 and 16—are due by the end of the year, but experienced observers note that it usually takes DOD at least 30 days to make up its mind in such cases. Allowing for the upcoming holidays, it may be the end of January before any action is announced.

The new series of bid packages on the 156-in. solid will be a turning point in the history of the national large solid-rocket motor program. For the first time, contracts will be directed toward development of specific launch systems rather than mere feasibility demonstrations. SSD also expects that from now on the Air Force 156-in. program will stand on its own feet, rather than ride the coat-tails of NASA's problematic 260-in. program.

NASA officials remain noncommittal about the future of that program, which continues to be a state-of-the-art advancement effort. To date, a large part of the 156-in. program has been justified as subscale development for the 260-in. motor.

• **Program objectives**—Ultimate goal of the Air Force 156-in. program will now be a solid-propellant launch vehicle capable of orbiting a wide variety of payloads—as yet unspecified—or launching massive weapons or payloads on suborbital trajectories. It will be possible to assemble it in three- or four-stage configurations.

A generally successful static firing of the Bid Package Three 156-incher was conducted last week by Thiokol Chemical Co.'s Wasatch Div. at Brigham City, Utah. Afterward, Brig. Gen. Joseph S. Bleymaier, SSD commander, said the test proved that the launch system envisioned by the Air Force can now be designed without fear of formidable new technological obstacles or prolonged, expensive new development.

Col. Harold W. Robbins, SSD director of the large solid-rocket motor program, said "it is now proven that such motors are scaleable. We can increase size without causing combustion instability and can predict action time and performance within tenths of a percent."

As part of its contract obligation on Bid Package Three, Thiokol has turned over the used case to SSD. As government-furnished equipment, it will be reloaded and refired by whatever contractor wins Bid Package 14. Had the case been damaged in the static firing last week, it might have delayed that part of the program by as much as six months. The case of the Bid Package Two motor will also become Air Force property for re-use in Bid Package 13 after it is fired sometime in February by the Thiokol Space Booster Div., Brunswick, Ga.

Both cases were built for Thiokol by Excelco Developments, Inc. Since nozzles are attached by bolt-on flanges, it will be possible to apply different nozzle and thrust-vector-control designs.

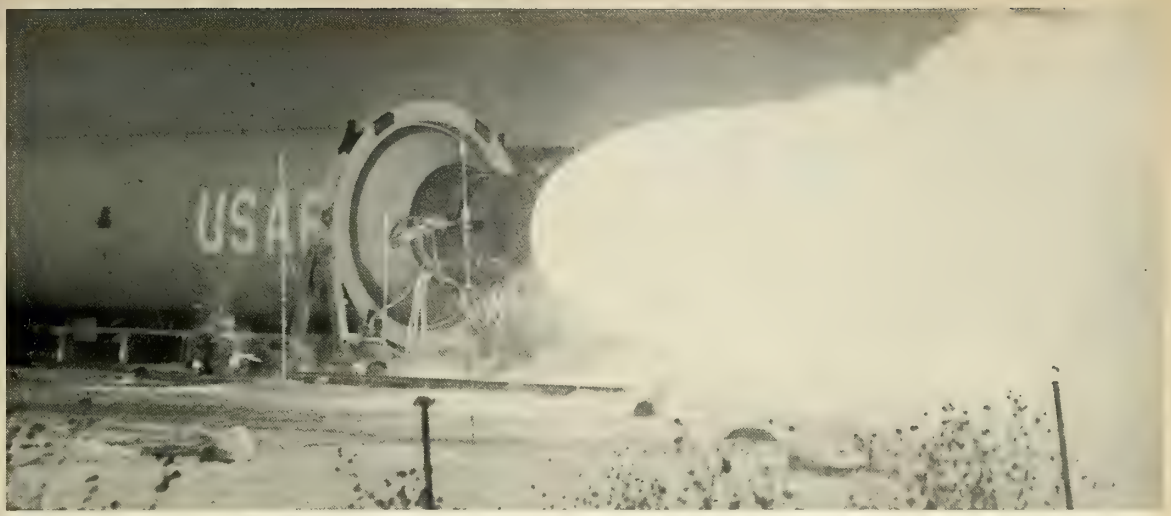
The Bid Package Three motor was regarded as flightweight hardware and had a propellant mass fraction of nearly 0.90. One primary goal was a demonstration of the feasibility of fully gimbaled nozzle thrust-vector-control for solid rockets. Although somewhat heavier than other TVC devices, the gimbaled nozzle does not intrude in the exhaust plan or degrade thrust.

During the successful static test, the gimbaling duty cycle—a function of thrust vector angle from the center line and angular rate—was approximately three times as severe as would be expected in a routine flight. Maximum thrust deflection was about five degrees, and the time required to swing from hard-over in one direction to hard-over in the opposite direction appeared to be a little more than one second.

• **Firing results**—During the 130-sec. test run, the Thiokol motor developed the planned chamber pressure and a thrust of nearly 1.5 million lbs. After 99.6 secs., excessive nozzle erosion created a notch in the edge of the expansion cone and rapidly cut the notch back toward the strong gimbal ring that reinforces the nozzle throat.

With its structural integrity destroyed, the stress of pressure, temperature and the accelerations of the gimbaling duty cycle shattered all of the cone downstream of the steel ring. Since the nozzle throat remained intact, the rocket continued to operate with only an 8% reduction in thrust and no change in chamber pressure.

The cone was made entirely of ablative-cooled impregnated carbon fabric without any sort of load-bearing metal shell. Probable fix would be to increase the thickness of the ablative cone rather than to add metal backing. The cone was constructed by a rosette lay-up process in which overlapping longitudinal cone segments are successively laminated, with opposite edges of each segment touching both inner and outer surfaces of the cone. The angled fabric



SUCCESSFUL STATIC FIRING of Bid Package Three 156-in. solid by Thiokol's Wasatch Div. last week.

segments act somewhat as a structural web to increase strength.

● **Nozzle design**—The Thiokol gimbaled nozzle is built on the ball-and-socket principle, with its center of rotation and the split-line between the movable and fixed parts of the motor upstream of the nozzle throat where exhaust flow is subsonic.

Metal parts in the throat and converging part of the nozzle are protected from direct contact with the exhaust flame by ablating plastic. The gap between the movable and fixed parts of the nozzle is only about 0.1 in. It is sealed by a Viton-A rubber O-ring.

The distance through the gap between the flame and the O-ring is about 10 in. This space is packed with highly viscous silicone grease to protect the ring. Some of the grease is entrained by the internal flow and more is extruded when the nozzle is moved to vector thrust, but the loss is not enough to call for resupply during motor burn. Longitudinal loads upon the movable nozzle are picked up by the gimbal rings to prevent them from jamming or deforming the ball and socket.

● **Motor position and design**—Aft-end ignition was used to start the horizontally mounted 777,000-lb (weight) rocket. A 43,000-lb.-thrust solid rocket was rail-mounted to fire its exhaust up the length of the circular charge port in the 156-in. propellant grain. Milliseconds later, explosive bolts released the igniter motor and it propelled itself downrange and out of the way of the exhaust from the larger motor.

The 78-ft.-long, 156-in.-dia. rocket was constructed and loaded in three segments, with V-shaped gaps between propellant grains at the joints configured to keep burning area, chamber pressure, and thrust constant during firing. When it is reloaded for Bid Package 14, only the head and aft segments of the case will be used. The cases are made of a Martensitic steel—18% nickel. The new motor is to deliver 1.1 million lbs. of thrust for 70 seconds.

The Thiokol Space Booster Division 156-in. solid rocket to be fired in the spring will produce about 3 million lbs. of thrust—twice that of the Wasatch Div. motor. The additional thrust is obtained by adding one more segment and using a faster-burning version of polybutadiene acrylic acid-ammonium perchlorate propellant, which will also be used in Bid Package 14 if Thiokol wins it. The characteristics of the faster-burning propellant are still within requirements for class-two non-detonable propellants.

The Air Force-NASA large solid rocket motor program is under management of Space Systems Division, (Air Force Systems Command), with technical management by Rocket Propulsion Laboratory at Edwards AFB, Calif. ■

More Surveyor Delay is Foreseen

FURTHER SLIPPAGE appears to be developing in the *Surveyor* program, even though NASA hailed the Dec. 11 launch of its *Centaur* launch vehicle as a success.

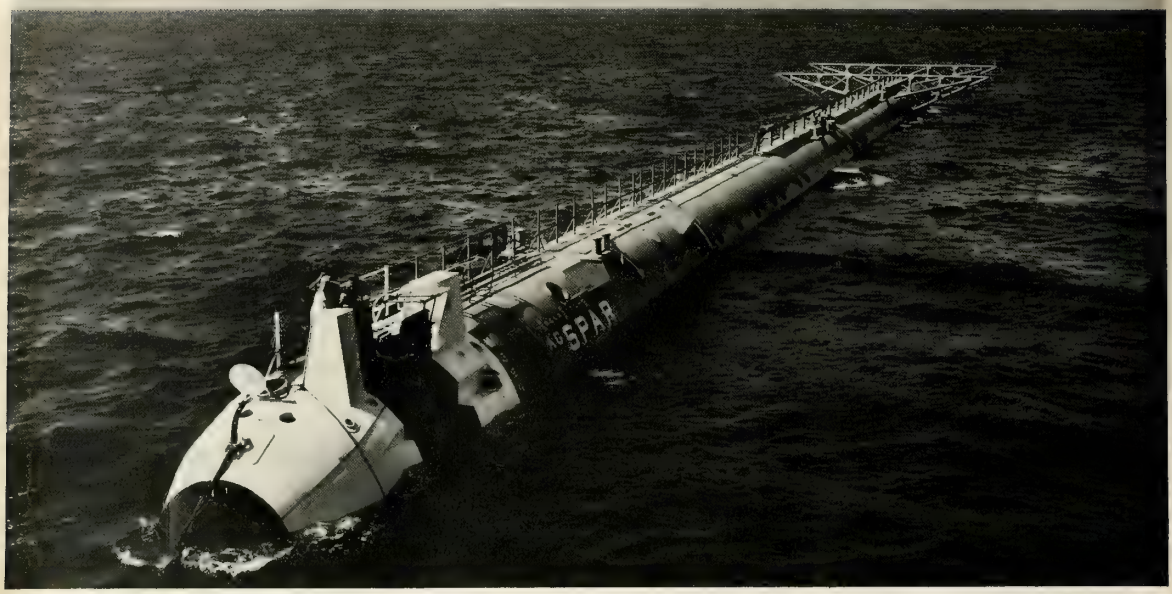
The first spacecraft the space agency hopes will take pictures of the lunar surface will be the fourth in the *Surveyor* program. Before that, four development flights of *Centaur* will have to be made in 1965, and then three engineering test models of the spacecraft will have to be launched. Since NASA was able to launch only two *Centaurs* in 1964, the time required to get off seven flights will probably push back the first soft landing of *Surveyor* on the Moon until late in 1966.

NASA called the *Centaur 4* flight a success even though the planned re-start of the upper stage's engines failed to take place. The launch with the heaviest payload ever lofted by *Centaur*—41,027 lbs. —got off from Cape Kennedy at 9:25 am. (EST), and after a nominal first burn the *Centaur* went into a parking orbit of 101.2 miles perigee and 107.3 miles apogee.

The attempt to restart the engines 25 minutes later failed when the stage began to tumble and roll in its orbit.

Late last week, NASA officials said that the most likely cause for the tumbling was not trouble with the guidance system, but rather the failure to keep the liquid hydrogen in the bottom of its tank. If it sloshed around, as they believe, it could easily have caused the tumbling.

NASA said that all prime mission objectives had been met, including the demonstration of the structural integrity of the *Atlas-Centaur* during powered flight, testing of the guidance system which was flying closed-loop for the first time, verification of the structural and thermal integrity of the *Centaur* nose fairing and insulation panels, and verification of the performance of the jettison systems for the nose fairing and insulation panels.





SPAR Goes to Sea

FIRST PICTURES of sea trials of SPAR (Seagoing Platform for Acoustics Research) were taken off Mayport, Fla. The objective was to upend the vessel for the first time, check its stability and operating equipment prior to installation of oceanographic equipment next month at the Navy Yard Annex, Washington, D.C. The vessel is expected to be operational early next summer.

SPAR is a 354-ft.-long, 16-ft.-dia., cigar-shaped vessel, towed in the horizontal attitude, then ballasted to a vertical attitude to become a stable platform (M/R, Aug. 3, p. 27). It displaces 1,370 tons horizontal, 1,720 tons vertical. Preliminary design was done at the Naval Ordnance Laboratory, White Oak, Md., but the final design was by M. Rosenblatt and Sons, Inc., naval architects and marine engineers of New York.

In the pictures shown here, the vessel reached a draft of 302 ft., its approximate operating attitude. SPAR is said to be stable in rough water when its maximum heave will be about one fps. Rough water is defined as sea-state four—4- to 8-foot waves.

SPAR is unmanned and its scientific data is expected to contribute to learning more about the ocean for Navy ASW work. Builder is Aerojet-General Shipyards, formerly Gibbs Shipyards of Jacksonville, Fla. ■



Technical Countdown

ELECTRONICS

Laser Beam Studied With Liquid Crystals

Liquid-crystal sensors are being employed by Westinghouse scientists in Pittsburgh to study laser-beam infrared far-field patterns. Described as extremely temperature-sensitive, thin films of the cholesterol-compound sensors undergo unique color changes (from red to green) under IR irradiation, providing useful data concerning laser operating characteristics. The detector itself consists of a thin film of the liquid crystals supported on a blackened membrane installed within a vacuum chamber. The film is illuminated on one side by a mercury lamp and an adjustable heat lamp. The laser beam is directed at the flat film surface on the other side. The film is observed from the mercury-lamp-lit side.

GaAs Generator Operated Continuously

A gallium-arsenide (GaAs) microwave generator has been operated continuously at room temperature by IBM's Thomas J. Watson Research Center, Yorktown Heights, N.Y., opening up practical use of such devices in microwave communications systems. Such devices previously required pulsed operation only due to rapid high temperature build-up in the crystal block. By increasing resistivity with specially built crystals and improving heat transfer with conducting copper rods, IBM researchers claim satisfactory control. Experimental GaAs crystals used are about 30 microns thick, with square cross sections varying from 175 to 250 microns, and have been operated in the 4 to 7-gc range. Input is 1.5 watts; output about 17 μw.

Thumbtack Accelerometer Developed

A new miniature piezoelectric accelerometer, developed by the National Bureau of Standards, presents an extremely low mechanical impedance to a vibrating body, permitting the precise location of vibration measurements to be known. The pickup, requiring only tip control with a surface—less than 0.20 mm^2—is a barium titanate piezoelectric disc sandwiched between a hardened steel probe and a cylindrical steel base. The probe is a 30-degree cone with a sensing tip of 0.25-mm radius. The whole transducer resembles a thumbtack and has been so named by NBS researchers.

PROPULSION

Orbital Filament-Wound Tank Ordered

Aerojet-General Corp. will design a subscale filament-wound storable liquid propellant tank that could be placed in orbit as an experiment aboard a space vehicle. Work is under a $193,000 Air Force contract aimed at achieving weight savings in rockets and spacecraft. Development program will test various resins and liner materials with three propellants —Aerozine-50, nitrogen tetroxide and chlorine trifluoride. Liner materials will include organic polymers, metal foils and laminates of metals and polymers. Twenty 8-in. oblate-spheroid tanks will be built and tested using the storable propellants at varying temperatures for periods up to a year.

ASTRONAUTICS

Meteorological Probe Launches Successful

The Navy has completed first launches of what it calls the only available low-cost probe capable of carrying a 12-lb. payload to altitudes above 70 miles. The probe is the new *Sidewinder-Arcas* meteorological rocket developed by the Naval Missile Center, Pt. Mugu, Calif. NMC mated two standard rockets, the *Arcas* for the upper stage and the *Sidewinder* for the booster. Designed to probe the upper atmosphere during spacecraft launches, the vehicle will carry a metallized plastic sphere which will be ejected and inflated at altitude for radar tracking during descent.

Bubble Satellites Claimed Feasible

Formation of extremely large spheres in space by blowing them as bubbles looks feasible according to studies carried out by Astro Research Corp., Santa Barbara, Calif., for NASA Headquarters. Having no structural rigidity, a bubble has perfect spherical form, and is not subject to thermal distortion. The technique promises space structure sizes hitherto unattainable with very low masses. A 1,000-ft.-dia. *Echo II* type sphere could be blown from 200 lbs. of viscous material, yielding 2-micron film thickness. Vacuum inside sphere would far surpass those obtained in laboratories and so enable vacuum deposition of an internal metallic film for communications purposes. Other applications would be use of large sphere to reveal planetary upper atmosphere densities.

SPACE MEDICINE

Impact Bladder Tested Successfully

A fluid-filled "bladder" may offer the best form of protection to astronauts during impact accelerations, a study at Northrop Space Laboratories indicates. Using guinea pigs, the investigators compared impact damage using the bladder device to that encountered with total water immersion in a closed capsule and contoured protection. The fluid-filled garment produced less damage to the air-containing organs such as the lungs and alimentary tract than did water immersion, and less damage to the spleen and liver than the contoured couch. It seems to offer the same advantages in minimizing internal organ displacement as does water immersion, but without the risk of generating high hydraulic pressure pulses, they said.

Centrifugal Force Nullifies Inactivity Effects

A test in which centrifuge rides were used to nullify the effects of prolonged bedrest was performed by the Douglas Missile and Space Systems Div. for the Air Force and, reportedly, has produced encouraging results. Five college students underwent 42 days of total bedrest, except for 30-minute periods each day on the centrifuge starting with the fourth week of bedrest. A net hammock connected to an electric hoist was used to transfer the subjects from their beds to the centrifuge, so that they would not disturb the results of the test by having made any other movements. After the test period, the subjects were reportedly able to stand and walk without any ill effects. Data are being evaluated.

Post-Apollo Lunar-Orbit Experiment Recommendations Detailed in Report

by Michael Getler

SPACE AGENCY SCIENTISTS have completed the first of three preliminary but comprehensive Mission Definition Documents detailing the objectives and potential scientific experiments to be carried on by manned spacecraft in the period immediately following the initial *Apollo* lunar landing.

The first report outlines experiments which NASA scientists currently view as potential payloads for manned lunar-orbiting vehicles of the so-called *Extended Apollo* design (M/R, Nov. 30, p. 52).

It was prepared by the Advanced Missions Branch of the Manned Space Science Program within the Office of Space Sciences and Applications (OSSA), in cooperation with the Office of Manned Space Flight (OMSF).

The second document, covering manned Earth-orbital operations, is also being developed within OSS&A in cooperation with OMSF, and is expected to be completed early in 1965. The third report, covering manned lunar surface operations, is being written by the Marshall Space Flight Center in cooperation with NASA headquarters, and is also due to be submitted early next year.

Scientific aspects of the reports are being developed under the direction of OSS&A's Willis B. Foster (director of the Manned Space Science program) and Dr. Peter C. Badgely (chief of Advanced Missions), in cooperation with OMSF's William Taylor (director of Special Manned Space Flight Studies) and Maurice Raffensperger (director of the Manned Earth Orbital Missions Studies) concerning spacecraft systems and engineering.

While the reports are viewed as "first iterations only," according to NASA, their very existence, and the widespread scientific inputs which they reflect, signals a major step forward in the space agency's attempt to define in detail an integrated program of early post-*Apollo* manned exploration.

NASA officials feel that with the reports in hand (particularly the Earth-orbital and lunar-orbital projects), a second go-around will see the overall *Apollo Extension System* (*AES*) program definitized within the next few months.

While the three portions of the *AES* effort will have distinctly different scientific missions, the two programs directed at lunar exploration will be highly complementary, with the lunar-orbital data used to extend the relatively limited-range early lunar surface traverses and to verify data gathered by other manned and unmanned lunar probes and sensors.

● **Lunar-orbit AES**—NASA says the basic *Apollo* lunar orbiting spacecraft will perform three missions. These include:

—*Surface Exploration Support*—which basically involves delivering three astronauts to lunar orbit and then remaining in orbit for up to 14 days while two astronauts descend to and explore the lunar surface. This requires an extended-life *Apollo* Command and Service module in orbit and two extended-life LEM's on the surface; one delivered unmanned to serve as a shelter and laboratory for the two-man crew landing later.

—*Mapping and Survey*—which can be accomplished in four days in a low-inclination lunar orbit and requires addition (probably to the Service Module) of a camera subsystem for mapping and high-resolution stereo reconnaissance, and some orbit-to-surface probe equipment which could be rack-mounted on the spacecraft. A viewfinder is also being studied for pointing the cameras, acquiring targets of interest, and guiding deployment of the surfacing probes.

—*Extended Lunar Orbital Survey*—represents the primary mission for these spacecraft, and the one for which most of the new experimental packages would have to be developed. A series of missions is envisioned in which two or three astronauts would be placed in a lunar polar orbit for up to 28 days. NASA points out that this stay time, plus the transit to and from Earth, would mean increases in the lifetime of several *Apollo* subsystems, particularly power and life support, to about 35 days, in addition to taking on more expendable supplies. They say one answer to extended life support and power needs, and additional working and living space for this mission, might be use of the LEM ascent stage.

While the extended survey operation would carry multi-spectral photography sensors and various electromagnetic sensors, it probably would also keep on board the cameras, probes, and viewfinder developed for the mapping mission.

Discussing the design of the viewfinder, NASA says it wants a device which has the maximum angular range possible and also states that some ability to vary the magnification would be desirable. Since the orbiter's relative ground speed will be rapid, the viewfinder and the on-board photographic sensors will have image-motion compensation devices, though there are some possible trade-offs between exposure times, film speed, resolution, and system weight. The chosen system might also have a small telescope for planetary surface observations.

Estimates of some of the major operating parameters of the potential experiments for the manned lunar orbiter appear in the accompanying chart (p. 23). Following are further details about the reports.

● **Photographic mapping**—NASA

says the proposed mapping and survey system will include a high-resolution camera for lunar-landing site selection, certification of site integrity, and high-resolution photos of interesting landmarks; a cartographic camera for area mapping and landmark location; a stellar camera for precise spacecraft attitude determination during camera exposure; an altimeter and a clock.

The high-resolution camera must be capable of resolving low-contrast objects of a few feet on the lunar surface when the Sun angle above the local horizontal is between 10 and 40 deg. The mapping camera must provide an ability to locate various lunar sites and landmarks to a relative accuracy of 500 meters.

• **Multi-spectral photography**—This will be an attempt to differentiate between types of terrain by examining reflectivities in a number of different, and separately recorded, wavelengths—a technique which is thought to be considerably superior to conventional color photography. Due to the large on-board film requirements with this approach, intermittent coverage of areas is likely; the crew will play a key role in selection of certain areas and periods when continuous photographic coverage may be desirable.

NASA is now conducting several studies of importance to this experiment. One calls for reconstructing conventional color photos from a set of multi-spectral images and applying color-enhancing techniques to the resultant photo. Another study is aimed at better definition of the color sensitivities of the human eye, to remove some of the subjective elements from lunar photo interpretation.

• **IR surveying**—Use of remote IR sensors is anticipated as a means to positively identify certain types of rocks and minerals. While IR obsorption, reflection, or emission spectral measurement techniques are used in various applications, NASA investigators feel that emission analysis will be the best approach open to orbital spacecraft; they believe there is great promise in measuring reflection of IR radiation from surface-roving vehicles.

• **Passive microwave experiment**—It is hoped that a stereoscopic brightness temperature map of the Moon, and estimates of gross surface roughness and surface dielectric constant, will be provided through passive microwaves. Scientists see the orbiter as a means to extend already-established microwave temperature mapping techniques into the three-dimensional surface and subsurface area, with resolution elements of 0.5-10 km, depending upon orbital height.

Microwave emission measurements may determine the nature of the layering in the lunar crust, NASA believes, through measurement of subsurface emission at various wavelengths corresponding to different depths. These data, in conjunction with other visual and IR sensor inputs, are also expected to make possible more definite conclusions regarding certain lunar terrain features and their origins.

It is also expected that surface dielectric and roughness measurements will be obtained from measurements of microwave emission at several look angles, wavelengths, and polarizations. This should supply more accurate estimates of lunar dust cover on parts on the surface, perhaps those which cannot be reached by surface exploration.

Earth-orbital sensor test phase will be highly important for these experiments. Within a year, NASA says, an advanced stereoscopic imaging microwave instrument will be developed for airborne testing, and this will no doubt feed development of the device to be used in lunar orbit.

• **Lunar-gravity measurements**—Primary objective is accurate mapping of the Moon's gravity field—particularly anomalous regions of the field—in the hope of gaining a better understanding of the internal construction, crustal rigidity and mass distribution. With development of highly sensitive instruments (M/R, Dec. 14, p. 32), scientists hope to be able to measure lunar anomalies of 1-10 milligals arising from structures 1-5 miles below the surface.

• **RF reflectivity**—By making measurements of HF and VHF reflectivities of the Moon's surface, NASA hopes to gain information on the dielectric and conductive properties down to con-

POSSIBLE EXPERIMENTAL PROFILE FOR A MANNED LUNAR ORBITAL MISSION

Experiment	Operating Spectral Range	Estimated Weight	Estimated Power	Estimated Dimensions	Spatial Resolution (from 20 n. miles)	Pointing Accuracy Required	
Photography	Visual range	400 lbs.-1,000 lbs.	20w-200w	2 cu. ft. + telescope	A few feet	±5° from vertical	
Multi spectral photography	0.35 to 1.5μ	20-40 lbs. + telescope	Less than 20w	1 cu. ft.	A few feet	0.1°-0.5° with image motion compensation	
Radar mapping	Multispectral radar	500 lbs.	500-1500w	Total 20 cu. ft. Antenna 10-30 ft.	20 sq. ft. at all altitudes	Low rate	
UV spectrometry	3000-4000Å	Passive 150 lbs.	150w	4½ cu. ft.	500 lines over 20° field	Coupling with camera system	Estimated Total Power 2kw
IR surveying	7-30μ	20-40 lbs.	5-10w	1-2 cu. ft.	0.7 sq. deg.	Hold for 0.5-2 seconds	
Gamma ray surveying	0.03Å	150 lbs.	15w	Not specified	20-200 miles	A few degrees	Estimated Total Weight 2,000 lbs.
Gravity surveying	—	10 lbs.	25w	3 cu. ft.		Order of an arc minute of angle	
X-ray spectroscopy	1-50Å	15 lbs.	5w	1 cu. ft.	7m x 60m	Non-critical	Estimated Total Volume 80 cu. ft.
Remote geochemical sensing	UV and short visible	20-80 lbs.	20w	2-8 cu. ft.	300 ft. from 20 n. miles	Angular rate less than 10°/minute	
Passive microwave experiment	—	Total 100 lbs.	200w	36 cu. ft. + antenna	0.5 km at 20 n. mi. altitude	±0.25 degrees total	
Meteoritic dust analysis	—	20 lbs.	2-4w	2 cu. ft.		Non-critical	
VHF reflectivity	Not specified	150-200 lbs.	200w	1-4 cu. ft.	10.5-5 miles from 20 n. mi.	Low-2 or 3 degrees	
Neutron albedo *	—	20 lbs.	10w	1 cu. ft.	2π	Not critical	

* Objectives under review

How to keep the upper hand . . . underground



bout Minuteman ICBMs:



Production

In a plant near Ogden, Utah, Boeing assembles Minuteman missiles for the U. S. Air Force. More than 700 (all on or ahead of schedule) have already been delivered to launch or test sites. In a recent 120-day period, Boeing delivered a complete 150-missile wing to the Air Force.

Testing

Boeing crews have launched, or assisted the Air Force in launching, more than 50 Minuteman missiles from Cape Kennedy or Vandenberg AFB. In addition to developing launch procedures and maintenance techniques for Air Force crews, Boeing provides training equipment and technical assistance.





Weapon System Integration

As weapon system integrator, Boeing installs the missiles at operational sites and assembles the complete weapon system for delivery to Air Force. Work involves command and control equipment, communications networks, security installations and underground quarters for Strategic Air Command crews.

Minuteman II

First firing of advanced Minuteman II was perfect, from launch at Cape Kennedy to direct hit in splash net near Ascension Island. A continuing improvement program has achieved heavier payload, greater accuracy and increased range.



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siderably greater depths than can be obtained using radar frequences. Behavior of crustal materials of the Moon as reflectors at these relatively low frequencies is largely unknown and should be of considerable interest. For example, unexpectedly deep penetrations could open the way to underground communication sites.

● **Radar imaging**—High-resolution side-looking radar, despite its high power and size demands, is believed to provide some unique advantages not available from optical mapping methods and is viewed as essential for a manned lunar orbiter. It is particularly suitable for tectonic mapping, since it displays some structural details which would go undetected photographically, particularly if they were illuminated vertically. The technique will allow mapping both dark and light sides of the Moon, completing a surface coverage in about 14 days.

● **UV absorption and luminescence**—This may yield specific data on the chemical composition of the lunar surface. NASA says that as a result of terrestrial studies, two highly sensitive systems may be developed which would require only slight changes for use in an *AES* orbiter.

● **X-Ray fluorescence**—NASA hopes to extend the rather well-known material analysis techniques usually conducted in the so-called hard X-ray region (0.3 Å–3Å) to the soft X-ray regime for surface atomic analysis of the Moon. The NASA report states that preliminary studies suggest that sufficient solar X-ray flux is available under "quiet" Sun conditions to make the measurements feasible. Possible ground resolution from orbital altitudes is on the order of 1 km sq.

● **Gamma ray mapping**—Identification of mineral deposits with distinctive gamma-ray spectra, measurement of cosmic-ray-induced radioactivity, and geochemical mapping of surface layers are the objectives of this experiment. Measurement of the natural component of the Moon's radioactivity will aid in determination of the heat balance. This in turn will be valuable in estimating the degree of differentiation undergone during the Moon's evolution.

● **Remote geochemical sensing**—NASA suggests that detection of trace metals near the lunar surface may be possible by means of applying new techniques for detecting spectral absorption characteristics which are said to be particularly well suited to a low-pressure environment. This type of experiment might also yield data on the presence of occluded gases near the lunar surface in quantities too small to be detected by other means.

● **Micrometeorite experiment**—The major objective here is to collect, intact and unaltered, cosmic dust particles from space with an *AES* lunar orbiter; they will be recovered for subsequent analysis in the hope of finding answers to questions concerning the lunar dust environment and the origin and source (possibly the Moon itself) of the particles. The development of various collection systems is well under way in the U.S.; some have already been flown aboard Earth-orbiting craft and other probes.

Inclusion of these experiments aboard a manned lunar orbiter will impose certain restraints upon the various *AES* spacecraft systems.

● **Spacecraft considerations**—For example, the choice of the lunar orbit, stay time, and height above the surface are all subject to some trade-offs. Maximum coverage for the experiments will be derived from a polar orbit, coupled with a stay time of at least one sidereal period (27.3 days). With this condition, the entire lunar surface will pass directly under the spacecraft. However, the NASA report points out that the requirement for a vertical view is not critical and a near-polar orbit combined with side-looking sensors would achieve the same effect.

The orbital altitude affects resolution of some experiments and power consumption of others. In general, lowering the orbit increases the performance of most experiments; however, the angular rate at which surface features pass through the field-of-view greatly increases (about 2 deg/sec. at 20 n. mi.), making demands on the image-motion compensation capabilities.

Spacecraft attitude stabilization may not be too critical if some experiments can be equipped with additional stabilization devices, says the report. The side-looking radar antenna however, might impose an overall stability requirement of about 3.5 deg/sec. on the spacecraft.

Orbit determination by means of NASA's manned space flight net and the DSIF is expected to measure spacecraft position to about 100 meters, and velocity to within ± 0.2 meters/sec. However, some form of altimeter will be essential aboard the orbiter.

Power requirement for the experiments is now estimated at between 2–2.5 kw.

Careful study will be given to the manner in which data is returned to Earth and to the selection of which data is returned. Present estimates indicate that only about 200 lbs. of data can be returned in the *AES* re-entry module. This would be equivalent to stored high-resolution photos of about 1/10 of the lunar surface. In view of this limitation, NASA scientists stress the importance of the astronaut as a critical selective agent.

In addition to physically returned data, the *AES* is expected to have an allocated telemetry bandwidth of 10 mc, according to NASA, which represents an increase in information bandwidth beyond the current *Apollo* communications system.

However, NASA says that present estimates indicate that allowable stored-data return, together with the telemetry capability, will still not be sufficient to return all experimental data to Earth. Therefore, much study will have to be made of the trade-offs between sending over each route and the possibilities of using new in-flight data reduction systems.

One other possible constraint may be the existence of exhaust and other gaseous material around the spacecraft —material which could contaminate the lunar atmosphere and hinder attempts to measure constituents in their original form. Measurement of the spacecraft environment prior to entering lunar orbit appears to be advantageous.

The NASA report also touches on some of the secondary, non-scientific roles that a manned lunar orbiter could perform; these include its use as a communications link, as a navigational aid to assist in precise surface location of equipment, and in a search and rescue role also associated with lunar surface operations.

● **Timetable**—The ground development and subsequent flight-test plan for *AES* missions looks something like this:

Mid-1964–early 1967: Experiment feasibility studies (many of these are already under way within various NASA and other governmental agencies, and universities).

Early–late 1965: Preliminary design studies of instrument requirements for spaceflight experiments.

Late 1965–mid 1966: Detailed instrument design and prototype development.

Late 1966–early 1968: Hardware development and integration with spacecraft.

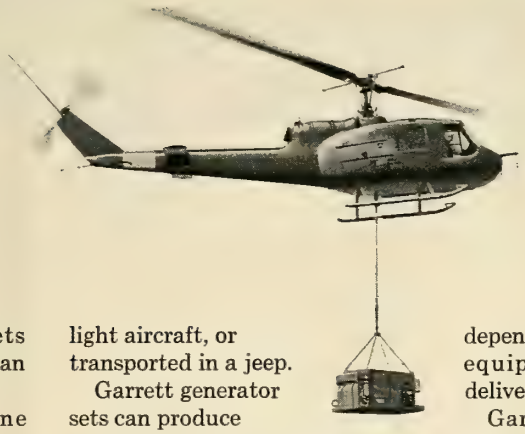
Mid 1968–early 1969: Testing in Earth orbit (probably using *Saturn IB*) for lunar orbit sensors and module.

Early 1969: Operational readiness for lunar orbital scientific survey mission.

Early 1969 —: Data returns and analysis from *AES* missions, with an established data center in operation at this time.

Though flight plans are still uncertain, NASA estimates that 2-3 lunar orbital survey flights, using the *Saturn V* launch vehicle, in increasing orbital inclinations and to 28-day durations, will be made during the 2-3 year period after the initial *Apollo* landings. ■

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Deep Submergence Project Calls For Five-Year Expenditure of $200 Million

Navy program aimed at establishing advanced sea-based deterrent; only beginning of what may become bigger deep ocean program

FIRST STEPS toward utilizing the deep ocean for an advanced sea-based deterrent have been taken with establishment of the Deep Submergence Systems Project (DSSP).

The program, as revealed to an unclassified industry briefing on Nov. 24, calls for spending $200 million over the next five years, but this is only the opening wedge in what the Navy hopes will be full exploitation of the ocean depths. DSSP is merely the public view of what is considered to be a sizable deep ocean program.

Dr. John P. Craven, chief scientist for the Navy's Special Projects Office, which is responsible for DSSP, told MISSILES AND ROCKETS in an interview last September that it would be "a long, long time" before the Navy would find it necessary to utilize all the concealment afforded by the ocean. At the same time, he noted that exploitation of technology should reduce substantially the extremely high costs and limited usefulness of present "balloons of the sea".

In particular, he felt that if materials and structures problems can be solved so that applications flow freely, costs of deep-ocean systems can be reduced to a point at which military applications become attractive. The immediate problem then is to get applications flowing freely and this is the problem at which DSSP is aimed.

Another factor contributing to the relatively leisurely cost-effective approach to the deep-ocean problem is the fact that Navy analyses now show that the *Polaris* weapons system will be effective into the 1980's. This is a long lifetime, as operational effectiveness of modern weapons is measured, which lessens the need for rapid-fire development of a new sea-based deterrent.

Two major inputs to evolution of the deep submergence program were the report of the Deep Submergence Systems Review Group (DSSRG) and the Project Seabed study of the Advanced Sea-based Deterrent.

The former panel was headed by Rear Adm. E. C. Stephan, (USN, Ret.). It was instructed "to review Navy plans for development and procurement of components and systems related to location, identification, rescue from and recovery of deeply submerged large objects from the ocean floor," as well as to recommend changes to these plans, to develop a five-year program for implementation of its recommendations and to recommend organizational means and responsibilities for implementation. The impetus for this panel was the Thresher disaster in which the nuclear attack submarine went down in 8,400 ft. of water with the loss of 129 men.

Impact of the second input—the Seabed study—is harder to evaluate, since results are still highly classified. However, of the four panels established during the study, one concerned itself wholly with deep-ocean technology. The other three panels covered weapons, systems and over-view and review.

● **Program purposely focused**—As outlined at the industry briefing, the deep submergence program is addressed to specific requirements of the Chief of Naval Operations as represented in four Specific Operational Requirements (SOR) and two Advanced Development Objectives (ADO). These, in turn, are drawn from recommendations of the Stephan committee. The CNO program calls for development of:

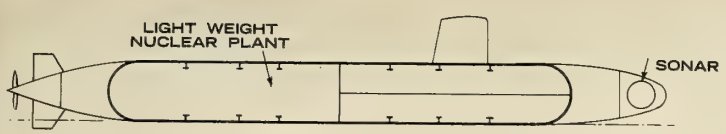
—Submarine location, escape and rescue system—including ability to locate both cooperative and uncooperative targets, escape from 600 ft. and rescue to submarine-collapse depths. This is to be achieved primarily by development of a small (12-14-man) submersible rescue vehicle that can be transported to the scene of a disaster by, and operated from, a specially modified nuclear submarine. In addition, the vehicle will be operable from surface rescue ships.

The Stephan committee recommendation was that six of these vehicles should be built. Three are specified in the CNO program. However, this was based on a 12-hour response time, while the CNO-SOR envisions a 24-hour response as acceptable. Funding for this phase of DSSP is expected to be $42 million—$13 million less than the DSSRG recommendation. This reduction is reflected by the smaller number of rescue craft to be built.

—*Large object salvage system*—with the ability to provide salvage of 1,000-ton hulls from 600 ft. (continental shelf depth). An ADO calls for a longer-range effort for salvage of 1,000-ton hulls down to submarine-collapse depths. Feasibility of this effort still must be determined.

DSSRG had recommended development of not only the 600-ft. and collapse-depth capabilities but also the capability to salvage 2,000-10,000 tons from 20,000 ft. The latter recommendation was rejected. Largely due to these reduced requirements, funding for the DSSP program was reduced $114.5 million from the Stephan committee recommendations—leaving $21 million to be spent on the 600-ft. capability and $11.5 million for exploration of the collapse-depth problem.

—*Deep ocean search, investigation and small object recovery system*—capable of search and light work down to 20,000 ft. A manned submersible vehicle will be developed for this purpose in two phases: first, a test vehicle able to recover objects weighting less than 10 tons and to dive to 6,000 ft. will be built; then, four vehicles with the same recovery ability but able to work at 20,000-ft. depths. These are to be operational by Fiscal Year 1970.



LEERS

LENGTH OVERALL	177'-0"
PRESSURE HULL DIAMETER	18'-0"
SUBMERGED DISPLACEMENT, TONS	1,100
SPEED IN KNOTS	15
SHAFT HORSEPOWER	2,000
TYPE OF POWER PLANT	NUCLEAR
ENDURANCE	NUCLEAR
PRESSURE HULL	3¼"T1-120
OPERATING DEPTH IN FEET	8,000

DRAWING OF Long-Endurance Experimental Research Submarine (LEERS).

These requirements are in concert with the DSSRG recommendations and the funding for this phase of the program is $93 million—an increase of $32 million over the DSSRG program. This increase, according to the Navy, is just an increase in accounting."

—Man-in-the-sea, continental shelf —an extension of the capability of free-divers to perform useful work down to 600-ft. depths. At present, men can work for 30 minutes at depths of 380 ft., with four hours required to surface them after this time. To achieve the 600-ft. depth, a new diving technique must be developed. "Recent tests," says the Navy, "indicate that both in terms of increased depth and bottom time . . . man can remain days or even weeks under the sea exposed continuously to ambient pressure without apparent ill effects, if provided the proper support equipment."

As an ADO, the Navy intends to investigate the greatest depth possible for a diver to do effective work within physiological limits. Ancillary equipment, such as the undersea shelter, submersible decompression chamber and tools, will also require development in addition to the life-support equipment and divert techniques. DSSRG had recommended a $34-million program, while the CNO requirements call for expenditure of $10 million.

Total spending for the five years is expected to be more than $200 million, although the official estimate which must be refined further (see table) places the five-year program at $181 million. A revised program change outlining the funding is to be submitted to the Dept. of Defense this week. Technical development plans to meet the SOR's and ADO's have been prepared and submitted to the Chief of Naval Material.

● **Critical factor: materials**—Limiting factor in the Deep Submergence program will be materials, particularly materials with the required strength-to-weight ratio. The fact that these deep submersibles will do useful work at great depths and have relatively great maneuverability means that the heavy bathyscaphs are unsuited for the Navy program. In addition, the combatant role that these vessels might perform further limits the selection of pressure vessel materials.

High-yield-strength steels of 150,000 psi and titanium of 120,000 psi yield strength are the principal materials under consideration. Titanium, however, has one major drawback—the cost of the material, estimated at 5½ times that of steel. If the vehicle is strictly noncombatant, the range of choice widens to include fiber-reinforced plastics with yield strengths of 200,000 psi and massive glass with a yield strength of 300,000 psi.

Three classes of deep-submersible vehicles are under consideration. They are differentiated by the amount of time that they will be able to work in the deep ocean. The first has an endurance of about 10 hours and is primarily for the submarine rescue mission. Buoyancy material would be syntactic foam, and the pressure vessel would be spherical. Silver-zinc batteries are thought to be suitable for this type of submersible.

In the second category is the 100-hour deep-diving vehicle, which would have a crew of four to six men. This would have a cylindrical pressure vessel capped by hemispherical ends. Its displacement would be approximately double that of the submarine rescue vehicle.

Finally, a submersible with 1,000-hr. endurance is to be built. This will have true mobility in the deep ocean and could serve as a test bed for combatant vehicles. The Long-Endurance Experimental Research Submarine (LEERS) shown on this page is how the Navy conceives this vehicle now. It would have an advanced nuclear powerplant requiring little or no maintenance and delivering 2,000-3,000 hp. Weight of the powerplant that the Navy is seeking is roughly 250 lbs/hp. Thickness of the pressure vessel is "about the same as a combatant submarine," Navy officials say, and its construction should utilize the sandwich structures familiar to the aerospace industry.

In addition to materials problems, the Navy lists a myriad of problems inherent to any new field of technology. Chief among these are bouyancy materials, lightweight powerplants, mating techniques for two submersibles, and manipulators. Propulsion systems also are a major concern.

● **Time schedule**—No substantial contract awards are expected in the DSSP until after July 1, 1965. This is primarily due to lack of funds; the first major increment of the program is in the FY '66 budget. Assuming that DDR&E gives the Navy a waiver on program definition, requests for proposals for parts of the program are expected to be sent to industry beginning in the spring.

If program definition is required, this schedule may be set back eight month. Most of the program, and particularly the SOR's are geared to providing the Navy a rescue and initial deep-sea operating ability by 1970. ■

SUMMARY OF DSSP FUNDING REQUIREMENTS

Capability	Item	Funded by fiscal yrs—Thousands 65	66	67	68	69	70
I	Submarine location, escape & rescue system (SOR)	1,145	6,550	14,850	10,670	4,895	3,545
II	Large object salvage system (SOR)	200	4,080	6,620	5,495	4,070	1,175
	Extended salvage depth capability (ADO)		1,835	2,565	3,350	3,750	
III	Deep ocean search, investigation & small object recovery (SOR)	1,320	12,050	24,635	15,810	20,980	18,095
IV	Man-in-the-sea, continental shelf (SOR)	335	2,735	3,105	1,470	1,470	1,470
	Man-in-the-sea, deep ocean (ADO)		1,045	1,045	1,450	200	200
	DSSP—STG	500					
	Totals	3,500	28,295	52,820	38,245	35,370	24,485

PROJECT TOTAL=$182,715,000

Martin-Orlando Begins Operation Of Unique Armament Research Facility

Company-funded center will be used for wide range of conventional warhead tests, explosive hardware research; primary goal is better non-nuclear weapons; other firms entering once strictly government field

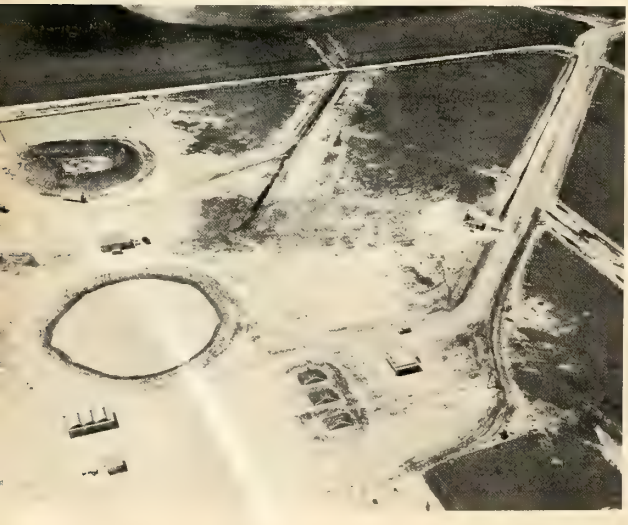
ORLANDO, FLA.—A new in-house armament research facility, complete from explosive loading to fragment-distribution instrumentation, has gone into operation here at the Martin Company's Orlando Div. Unique among industry R&D facilities of this type, the half-million dollar-plus armament center was built and equipped entirely with company money.

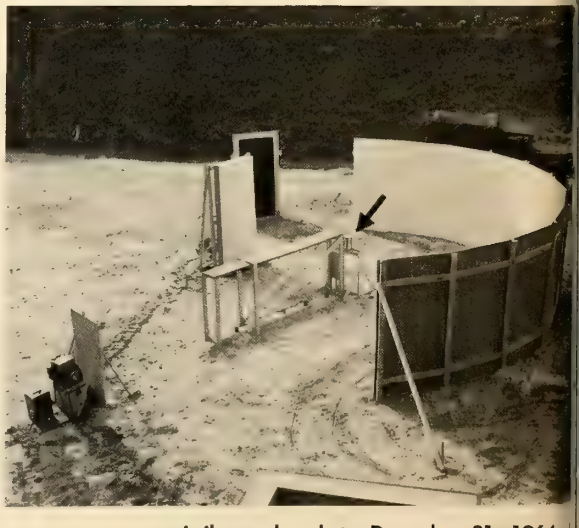
A number of programs are currently under way, some under Air Force and Army contract, and others company funded. Collectively, they cover a broad area of warhead research, including studies of hypervelocity fragment impact and projection phenomena, fragment dissemination, terminal effects and laser interaction. Work includes extensive experimentation in shaped charges as well as general blast effects and energy coupling.

The nuclear test ban is indirectly responsible for the Martin-Orlando interest and investment in armament research. The ban and the growing emphasis on limited warfare make it mandatory, company management feels, to better understand explosive, fragment and target phenomena which lead to new and better non-nuclear missile warheads (M/R, 9/28/64).

Traditionally, warhead research and development has been performed in government arsenals and laboratories. But industry is now beginning to assume a significant supporting role in warhead R&D. Martin is not alone in its decision to build and equip such facilities; several other aerospace companies also have initiated strong programs involving the various phases of the conventional munitions business.

According to Charles Borcher, manager of Martin-Orlando's engineering mechanics research laboratory—of which the armament center is part—warhead effectiveness can mean the difference between complete success and total failure of any weapon system. He contends that an optimized missile





with greatly improved lethality can best be achieved by building a warhead specifically to fit the mission and then provide a compatible guidance and delivery system to take it to the target. Since the warhead is the missile payload and the reason for its existence, it is the most important part of the system.

Warhead R&D at Martin-Orlando covers the spectrum from target definition studies to explosive-fragment target-interaction research. It proceeds from theoretical studies through actual design and preparation of the explosive, the fragments, and the packaging configuration for desired distribution patterns and fragment velocity. Theory and design are checked in actual firings and the results measured and evaluated against the "paper" projectiles.

● **Design by machine**—Target definition, said Borcher, involves a complete understanding of the target: its physical definition, mission, critical components, location, structure. This definition can then be used as the basis to determine proper kill criteria.

Martin studies have shown that targets can be defined and physically described on punched cards so that target vulnerability versus kill mechanism computations can be machine-processed. According to Borcher, all targets—vehicles, buildings, missile-launching sites, ships, aircraft, tanks, re-entry vehicles, satellites, or whatever—can be so cataloged, if their characteristics are known, and a standardized procedure established to match a target with an optimum warhead.

● **Research program**—Specific research program areas at Martin include the various concepts involved in the effectiveness of anti-personnel, anti-tank, anti-aircraft, anti-missile, and chemical munitions and laser effects on materials.

The goal of most of the explosive ordnance research currently being performed here is to greatly increase impact effects at the target. Toward this end, a wide variety of munition concepts have already been demonstrated as feasible in company-funded research and several patent disclosures filed.

Efforts to date have shown conclusively that the percentage of parasitic weight in a warhead may be reduced by increasing fragment weight and decreasing explosive percentage without degrading performance. Details of the techniques are classified, but warheads have been successfully tested to prove that the fragment energy per pound of explosive can be double that obtainable from more conventional techniques. The ability to control fragment pattern, velocity, and direction has been demonstrated in limited experiments.

Several dissemination techniques for controlling pattern and velocity have been investigated. These are believed by the researchers to offer several major advantages including high-density packaging, increased fragment mass, improved explosive and fragment energy coupling, and increased impact momentum.

Martin has done considerable work in the derivation of analytical techniques and computer programming for predicting warhead design parameters and performance characteristics. This work, all classified, includes warhead design considerations, procedures, and formulas for computing warhead output mechanisms; computational techniques for determining effectiveness against various targets; and an assembly of data on existing types of warheads. It includes, in addition, an analytical procedure for defining fragment impact patterns as a function of warhead design parameters and the geometry of attack.

● **Laser studies**—Weapon studies at Martin-Orlando also include theoretical, analytical, and experimental work on the effects of laser beams interacting with matter. This company-financed effort includes investigations into the various effects present in high-intensity laser interaction: heat, shock, reradiation, and photoelectric, chemical and nuclear effects.

High-powered (over 100 joules) ruby lasers, both Q-switched and non-Q-switched, are used in experiments with metallic and non-metallic materials. Instrumentation is being developed as part of this program to measure electromagnetic radiation intensity, spatial distribution, and temperatures and stress generated in materials during laser irradiation.

● **Test facility**—The armament test facility is located on a 10-acre site about two miles from the main Martin plant. An elaborate system of control points and gates assures tight security as well as safety. Visitors to the area must have previous clearance and follow a prescribed route and schedule within the complex. During firings, and even during thunderstorms, all personnel movements are controlled by the main Control Center.

The test complex comprises a chemical test laboratory, initiator research building, explosives-loading research building, three special test cells for testing explosive devices, storage magazines, range instrumentation and control center. (It also includes a man-made pond presided over by a three-foot alligator mascot named "Charlie." Apparently oblivious to the nearby detonations, Charlie enjoys a monastic life interrupted now and then by range personnel who bring him hotdogs.)



LEFT, P. 32: Aerial view of Martin armament research center. Large test cell (upper left) is used for warhead fragmentation studies. RIGHT, P. 32: Explosive device (arrow) is set up for test in instrumented cell. Instrumentation includes (center, from top) light box, padded witness plates for measuring depth of penetration, and radiographic setup for employing 8-ft. film strip and six X-ray flash lamps. RIGHT: Results of munitions discharge are evident on metal witness plates. Impacts are cataloged as to number of hits and locations.



MARTIN ORDNANCE technicians assemble a typical experimental explosive fragmentation device employed for pattern and depth-of-penetration studies.



LUCITE MATERIAL sample shows internal fractures caused by 100-joule, over-1-megawatt, pulsed laser beam fired into the end of the rod. Laser-effects studies are company-funded.

Advanced explosive initiators, both exploding bridgewire and conventional devices, are built and tested in the initiator research building. It consists of six explosion-proofed bays for processing basic explosives, and pressing, loading, welding and testing initiators.

The different warheads and experimental explosive devices are fabricated and prepared in a separate explosives research building. Outer bays of the three-bay building contain the mixing, melting and casting equipment, all of which is remotely controlled from the center bay. All equipment operations are monitored by closed-circuit television in the center bay of the control room.

The three test cells are used for the testing of explosive and inert devices.

One is a general-purpose test cell used for the evaluation of small non-fragmenting explosive and inert devices. It contains high-velocity gas guns and shock-wave diagnostic tools.

The second cell is used for experiments of end-projecting explosive devices and the study of the interaction of hyper-velocity projectiles with various materials. These experiments are performed in a chamber that can be evacuated to study projectile flight and terminal effects in a high altitude (200.000 ft.) environment.

A circular revetment 20 ft. high surrounds the third, and largest, test cell, which is used for the study of fragmenting warhead models. The inside diameter of this arena is 80 ft. and witness plates to record fragment impacts can be arranged in a full circle around the device under test.

Data acquisition for fragmenting warhead models is done primarily with high-speed framing cameras, which record impacts on target plates, and by depth-of-penetration measurements.

A major range instrument is the trailer-installed Beckman-Whitley Model 192 Framing Camera. One of two in existence owned by non-government organizations, the $100,000 camera achieves an exposure rate of 1,400,000 frames per second. Up to 80 35-mm frames are exposed for each event. To obtain such exposure speed, the film strip is transported on a 6,000-rps turbine within a circumferential prism ring which reflects the event images from the principal camera optics around the turbine.

The camera van is located outside the arena, viewing the mirror-reflected event through a 2-ft.-dia. tube. Within the test cell arena, the munition or test device is illuminated by argon flash bombs. To prevent double film exposure, the final reflector into the light tube to the camera is destroyed by a separate detonator at a precisely preset time.

Film data can be reduced by the use of an optical scanner which enters the data on IBM computer cards. The cards can be fed into a computer, which automatically computes velocity and pattern distributions or any similar analysis as required. Automatic plotting equipment can produce the data in graphical form directly from the computer output.

All test cells contain general and coaxial instrumentation lines, power and firing circuits, and flash radiograph and framing camera equipment. The range instrumentation and control building houses the triggering system for the test cells and provides access control for the entire range area. Instrumentation includes basic recording and measurement devices as well as timing equipment for the Fastax framing cameras, six-channel 150-kv Fexitron flash radiographs, and the Beckman-Whitley framing camera.

Additional backup and supporting equipment, located in the main plant research laboratory or other remote area, includes rocket-engine exhaust facilities for high-temperature material evaluation, environmental test equipment and other storage magazines. ■

JPL Using Two Radar Techniques To Prepare Map of Surface of Venus

by Rex Pay

PASADENA, CALIF.—The Jet Propulsion Laboratory is currently producing a map of the surface of Venus.

Two surface features are clearly evident in radar returns from the planet. Data reduction now in progress will determine the size and shape of these and other features.

Radar mapping of Venus was carried out during the June conjunction from the Venus site of the Goldstone Deep Space Instrumentation Facility (DSIF). The experiment continued until the end of July.

● **Two methods**—Dr. Richard Goldstein of JPL says two radar techniques have been combined to probe Venus surface details.

The first involves transmission of a pure sine wave and spectrum analysis of the returned signal. The sine wave is smeared in frequency by Doppler shifts caused by the planet's rotation. Spectrum analysis maps contours of constant velocity relative to Earth.

Second technique is use of pseudo-random coding of the transmitted signal with accurate range gating at the receiver, to compare the radar returns at successive range steps of 11.5 miles, or any multiple of this step. This map contours at a constant distance from Earth. Nine range gates are used simultaneously.

A combination of the two techniques gives nine sets of spectra in which the effects of surface features can be clearly seen. A computer routine is currently combining the two sets of measurements into a map.

The features move at the rotation speed of the planet. Goldstein said that the period of rotation of Venus is now measured at a fraction less than the 250 days estimated in the past.

● **Some roughness**—The chief radar return from Venus indicates the planet to be a smooth reflecting ball. However, if the main reflection is suppressed by reversing the circular polarization of the receiving system, the rays that have been reflected twice from the planet's surface become discernible. Although 18 times weaker than the main return, this double reflected signal indicates surface features on Venus that look rough to the radar waves. That is, they have a roughness of the order of 12.5 cm.

An 85-ft. steerable parabolic dish and a 100-kilowatt transmitter were used for the mapping experiment. Average return signal from Venus amounted to 10^{-22} watts, or about 60 photons per second. Noise temperature of the receiving system is about 30°K.

At the measuring wavelength, 12.5 cm., Venus and the Moon have comparable roughness. Measurements made on other planets show that Mercury is rougher than Venus, and Mars is smoother. Jupiter is smoother still, but reflects radar signals from only one region.

● **Mapping technique**—The map of Venus being produced has coordinates along the contours of constant range (from Earth) and constant frequency shift. Dividing up the received signal into different ranges gives contours that on a smooth ball would be concentric rings centered on the point closest to Earth. Dividing the return according to received frequency gives a series of strips parallel to the planet's axis of rotation.

Mapping by combining these measurements is ambiguous, because there usually are two points on the planet's surface with the same line-of-sight velocity and range. To resolve this, the planet is mapped for two different inclinations of the planet's axis to the line of sight.

Resolution of this mapping technique is limited in practice by the signal-to-noise ratio. Time-of-flight measurements with 11.5-mi.-range gates have yielded a precision of ± 0.00003 seconds in an elapsed time of about 300 seconds.

A liquid-helium-cooled traveling-wave maser with a noise temperature of 10°K is used for detection of the signals returning from Venus. Continuous tuning of the receiver's local oscillator is needed to keep the radar return within the receiver's pass band, because of Doppler shifts due to orbital motions. This is carried out by commands from ephemeris tape.

The signal leaving the receiver is processed by a Packard Bell 250 computer and nine-channel correlation equipment, to give the signal strength and spectrum in each of nine adjacent range gates. The computer can type out the results or present graphs of signal power versus frequency. More complex data reduction is carried out at the main JPL computer facility. ■

STL Awarded $6.1 Million for ASW Work

A $6.1-million contract has been awarded to TRW Space Technology Laboratories for services "necessary to perform systems analysis, integration engineering, test support, technical support and engineering evaluation" of Navy anti-submarine programs and equipment. The pact covers 12 months.

Responsible to Rear Adm. C. A. Karaberis, manager of the ASW Systems Project under the Chief of Naval Material, STL expects to have 200 scientists and engineers assigned to the program in Washington, D.C., and Los Angeles. STL will have no line responsibilities but will act as a technical adviser to Karaberis.

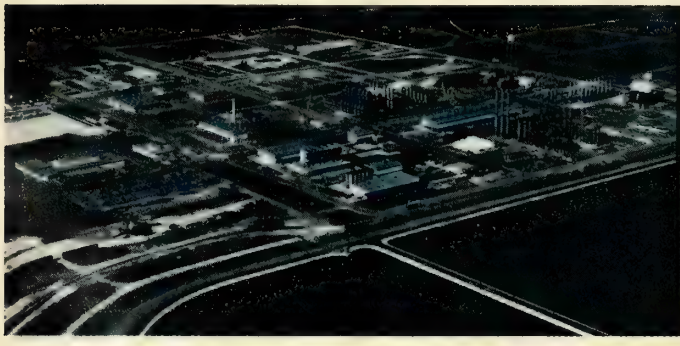
"This contract," Dr. Ruben F. Mettler, STL President, said, "is a challenge to TRW Space Technology Laboratories. It gives us the opportunity to apply the knowledge we gained through our work on many of the nation's ballistic missile and spacecraft programs to helping the Navy solve a critical defense problem."

A clause in the contract precludes TRW from supplying specific ASW hardware in areas in which comprehensive tasks in systems analysis and systems engineering have been assigned. This clause is "in accordance with DOD policy covering conflict-of-interest," the contract announcement said. There are no restrictions on TRW's bidding on other ASW hardware where "such comprehensive tasks" have not been assigned.

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Mergers and Acquisitions

Grumman Aircaft Engineering Corp., Bethpage, N.Y., has purchased Agawam Aircraft Products, Inc., of Sag Harbor, N.Y. Grumman purchased the aircraft and missile precision parts manufacturing firm for an undisclosed amount of money. Included in the acquisition was all land, buildings, machinery and equipment, existing inventory, and all work in process. . . . *C-E-I-R, Inc., Arlington, Va., has announced plans to purchase the Radio Corp. of America Data Processing Center in Washington, D.C. C-E-I-R will take over operation of the center Jan. 1.* . . . Alcar Instruments, Inc., of Trenton, N.J., has acquired General Instruments Corp.'s Ultrasonics Div. in Woodbury, Conn. The Ultrasonics Div. manufactures industrial cleaning equipment, which is intended to complement Alcar's line of hospital and specialty ultrasonic equipment.

New Facilities

Technology Incorporated, Dayton, Ohio, has begun a $550,000 expansion program to include a new 30,000-sq.-ft. building near Wright-Patterson AFB, Ohio. The Wright-Patterson facility will house administrative, engineering and research departments and will feature complete environmental control. Technology Incorporated performs work in the fields of systems engineering, meteorological and flight vehicle research, bioengineering, bioastronautics and data processing and analysis. . . . *General Astronautics Research Corp., Washington, D.C., has announced plans to transfer its operations early in 1965 from Washington to Huntsville, Ala. The firm specializes in research studies, scientific and technical analyses, state-of-the-art surveys, informational programs, data searches, art and graphic engineering, educational services, publishing and product development. Following the move to Huntsville, the company expects to expand its research, study and related programs to develop a series of astronomical products.* . . . Honeywell, Inc., has bought from the Clevite Corp. a 162,500-sq.-ft. facility in Waltham, Mass. The firm's Electronic Data Processing Div. will use the facility to consolidate its engineering, research and development groups into one location. The division's manufacturing facilities have been more than doubled during the past year, and now occupy more than 530,000 sq. ft. in Lowell, Brighton and Lawrence, Mass. . . . *Stevens Products, Inc., East Orange, N.J., manufacturer of glass-laminated electrical insulation components sold to electronics manufacturers throughout the U.S., is moving early next year to a new 11,500-sq.-ft. plant, also in East Orange.* . . . North American Aviation has broken ground on a 43,200-sq.-ft. building to house its Los Angeles Div. Aerospace Laboratory. The new lab will provide areas for work in chemistry, experimental sciences, metallurgy, organic materials, ceramics, fabrication feasibility research, special joining, creep testing and metal properties. . . . *Parker-Hannifin Corp. of Cleveland is constructing a new remote site near Newhall, Calif., for testing hazardous fluid systems. The firm's aerospace products group in Los Angeles will operate the facility. Parker-Hannifin manufactures fluid-handling and fluid control devices for missile/space, industrial and consumer applications.*

Missile/Space Activities

Monitor Electronic Co. has been formed in Orange, Calif., to engage in the field of telemetry transmitters. The company will design and fabricate a complete line of solid-state telemetry transmitters, with emphasis on the S and L bands at a power output of 2 to 5 watts and greater. Programs include sub-miniaturization of S-band transmitters and development of a line of economy solid-state transmitters. . . . *Watkins-Johnson Co., Palo Alto, Calif., on Jan. 1 will dissolve its Stewart Engineering Co. subsidiary in Santa Cruz as a corporate entity and reconstitute it as a division. As the Stewart Div. of Watkins-Johnson Co. the organization will continue to produce the line of backward-wave oscillators, controlled atmosphere furnaces and electronic equipment long identified with the Stewart name. No major changes in the organizational structure of Stewart are anticipated.* . . . North American Aviation has announced major changes and appointments in marketing and systems activities. Former assistant systems manager in the Minuteman Div. E. H. Manuel has been promoted to vice president-systems manager, succeeding E. N. Ljunggren, who has been transferred to the Los Angeles Div. as executive-vice president. Such internal Autonetics functions as central sales, customer and public relations, graphic arts, information control, the PRIDE employee incentive program, industrial security and regional office activities, all have been incorporated into a new division, Marketing and Public Relations, headed by E. O. Ethell, vice president. The Systems Div. has been reorganized to provide a program-oriented structure, tailored especially to requirements of PDP and pre-PDP contract studies leading to new defense systems.

International

Air Products and Chemicals, Inc., Allentown, Pa., is forming a wholly owned subsidiary, Air Products, G.m.b.H., to be headquartered in Dusseldorf, West Germany. The new industrial gases and related gas-using equipment firm will distribute, sell and provide associated application services. It will also sell cryogenic process plants designed and manufactured by Air Products.

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Published daily, except Saturdays, Sundays and Holidays by **American Aviation Publications, Inc.**, in Washington.
SUBSCRIPTION RATE: $20 a month, $110 for six months, $220 a year, postpaid. Quantity and deferred mailing rates on request.
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contracts and procurements

AWARDS

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$455,466—**McDonnell Aircraft Corp.,** two contracts for work on the *ASSET* program.

$201,600—**Western Electric Co., Inc.,** New York City, for missile-borne guidance equipment.

$200,000—**Electro-Optical Systems, Inc.,** Pasadena, Calif., for ion thruster systems for orbital flight.

$181,065—**Kollsman Instrument Corp.,** Elmhurst, N.Y., for investigation of space position fixing techniques.

$95,786—**Sylvania Electric Products,** Williamsville, N.Y., for a 12-month study of an electronically steerable array for space vehicle applications.

$77,949—**Honeywell, Inc.,** Minneapolis, Minn., for a study of aerospace photographic reconnaissance.

$71,000—**Ling-Temco-Vought, Inc.,** LTV Astronautics Div., Dallas, for *MOL* extra-vehicular activity experimentation.

$63,761—**Radio Corp. of America,** Aerospace Systems Div., Burlington, Mass., for additional work on a classified study.

$61,863—**Radio Corp., of America,** Aerospace Systems Div., Burlington, Mass., for a variable point guidance equation study.

$59,000—**Thiokol Chemical Corp.,** Wasatch Div., Brigham City, Utah, for labor, equipment, materials and supplies to conduct aging and surveillance testing of first-stage LGM-30A missile motors.

$45,000—**Boeing Co.,** Aerospace Div., Seattle, for *X-20A* cryogenic supply tankage and servicing equipment.

$35,285—**Radar Design Corp.,** Syracuse, N.Y., for investigation and study for field intensity probe instrumentation.

$34,982—**Radio Corp. of America,** Missile & Surface Radar Div., Moorestown, N.J., for work on traverse antenna feeds.

ARMY

$8,079,003—**Malan Construction Co.** of Koppers Co., Miss., for construction of S-II test complex at NASA's Mississippi Test Facility.

$2,376,604—**Sperry-Rand Corp.,** Salt Lake City, Utah, for *Sergeant* missile body sections.

$562,102—**Raytheon Co.,** Andover, Mass., for high-power illuminator radars for the *Hawk* missile system.

$266,912—**Rentenbach Engineering Co.,** Knoxville, Tenn., for construction of a rocket propulsion research laboratory at Arnold Engineering Development Center, Tenn.

$200,000—**Rohm and Haas Co.,** Redstone Arsenal Research Div., Ala., for a program of motor evaluation of advanced propellants at Redstone Arsenal, Ala.

$197,698—**Brown Engineering Co.,** Huntsville, Ala., for engineering support services in the areas of PERT, graphic arts, and re-entry data analysis for *Nike-X* systems.

$158,184—**B. B. McCormick & Sons, Inc.,** Jacksonville, Fla., for construction of missile instrumentation stations and other facilities at the Eastern Test Range, Patrick AFB, Fla.

$74,000—**Aerosystems International, Inc.,** Fairfield, N.J., for a 12-month research program for development of a self-pumping rocket (air cycle).

$56,688—**Raytheon Co.,** Andover, Mass., for missile system ground support equipment.

NAVY

$3,515,988—**General Dynamics Corp.,** Pomona, Calif., for continued work on *Terrier* and *Tartar* air defense missiles.

$2,993,662—**North American Aviation, Inc.,** Anaheim, Calif., for repair work on *Polaris* submarine navigation equipment.

$1,098,800—**Westinghouse Electric Corp.,** Baltimore, for continued R&D on Mark 48 torpedoes.

$185,500—**Rocket Power, Inc.,** Mesa, Ariz., for rocket motors.

$175,000—**Fairchild Camera & Instrument Corp.,** Du Mont Laboratories, Clifton, N.J., for continuation of development work on an electrostatic variable image magnifier tube.

$103,647—**Radio Corp. of America,** Missile & Surface Radar Div., Moorestown, N.J., for further work on AN/FPQ-6 and AN/TPQ-18 radars.

$79,597—**General Dynamics Corp.,** Pomona, Calif., for *Terrier* missile equipment repair parts.

NASA

$19,055,953—**George A. Fuller Co.,** Los Angeles, for construction of a lunar launch pad, to be known as Pad B of Launch Complex 39 at Merritt Island, Fla.

$2,000,000—**Motorola, Inc.,** Military Electronics Div., Scottsdale, Ariz., for construction of a test model for a system to measure position and velocity of spacecraft and launch vehicles for Marshall Space Flight Center.

$1,000,000—**Computer Applications, Inc.,** Silver Spring, Md., for computing services for Goddard Space Flight Center.

$1,000,000—**Walter Kidde & Co., Inc.,** Belleville, N.J., for six reaction control systems for the *Applications Technology Satellite* program.

$357,873—**Greenhut Construction Co., Inc.,** Pensacola, Fla., for construction work on the Components Test Facility Building at Marshall Space Flight Center.

$132,600—**American-Standard Advanced Technology Laboratories,** Mountain View, Calif., for a stellar-attitude measuring system.

$118,545—**McDonnell Aircraft Corp.,** St. Louis, for study of arc-jet propulsion devices.

$77,000—**United Technology Center,** Sunnyvale, Calif., for heat radiation measurements of solid propellant rocket exhaust gases.

$64,000—**Beckman Instruments, Inc.,** Fullerton, Calif., for development of an optical system for measuring air density at high altitudes.

$54,525—**Beckman Instruments, Inc.,** Scientific & Process Instrument Div., Fullerton, Calif., for study of detection of extraterrestrial microorganisms by microcalorimetry.

$39,918—**Ball Brothers Research Corp.,** Boulder, Colo., for Sun sensor design study, two laboratory model Sun sensors and one set of breadboard electronics.

$38,245—**Space-General Corp.,** El Monte, Calif., for structural load and deflection test of an *Aerobee 350* machined tank assembly.

$31,872—**Booz, Allen Applied Research, Inc.,** Bethesda, Md., for a portable data acquisition system.

INDUSTRY

$2,000,000—**FMC Corp.,** San Jose, Calif., from **The Boeing Co.,** Seattle, for assembly and test of a support, suspension and alignment system for the Air Force *Minuteman II* ICBM program.

$300,000—**Applied Technology, Inc.,** Palo Alto, Calif., from **ITT Federal Laboratories,** Nutley, N.J., for design and production of a series of advanced VHF and UHF receivers.

ARMS CONTROL AND DISARMAMENT AGENCY

$249,400—**North American Aviation, Inc.,** Downey, Calif., for a one-year study program of operational guidelines and advanced technology in the use of sensors and multi-sensor systems for arms control inspection.

NATIONAL BUREAU OF STANDARDS

Fairchild Hiller Corp., Space Systems Div., Rockville, Md., for development of an experimental rocket-borne ionosphere sounder (undisclosed amount).

REQUESTS FOR BIDS

GENERAL PROCUREMENTS

National Aeronautics and Space Administration
Goddard Space Flight Center
Greenbelt, Maryland
Attn.: Contracting Officer, Code 248

Negotiations underway with Philco Corp., Western Development Laboratories, Palo Alto, Calif., for RFP for modification of the Mojave 40-ft. antenna facility as an ATS ground station. RFP due 1/15/65. Those interested in subcontracting opportunities should contact the above firm.

National Aeronautics and Space Administration
Marshall Space Flight Center
Huntsville, Alabama

NASA issuing RFQ 1-5-80-00263 for a study and investigation of principles, methods and equipment for providing a transducer with a direct digital output, and to design, develop and fabricate three prototype pressure transducers with a direct digital output. Requests for RFQ package should be addressed to Mr. J. McMurray, MSFC.

Fort Monmouth Procurement Division
U.S. Army Electronics Command
Fort Monmouth, N.J. 07703

RFQ's to be issued around Dec. 21 for a study to determine the vulnerability of the improved *Nike-Hercules* missile system to electronic countermeasures.

Office of Naval Research
Washington, D.C.

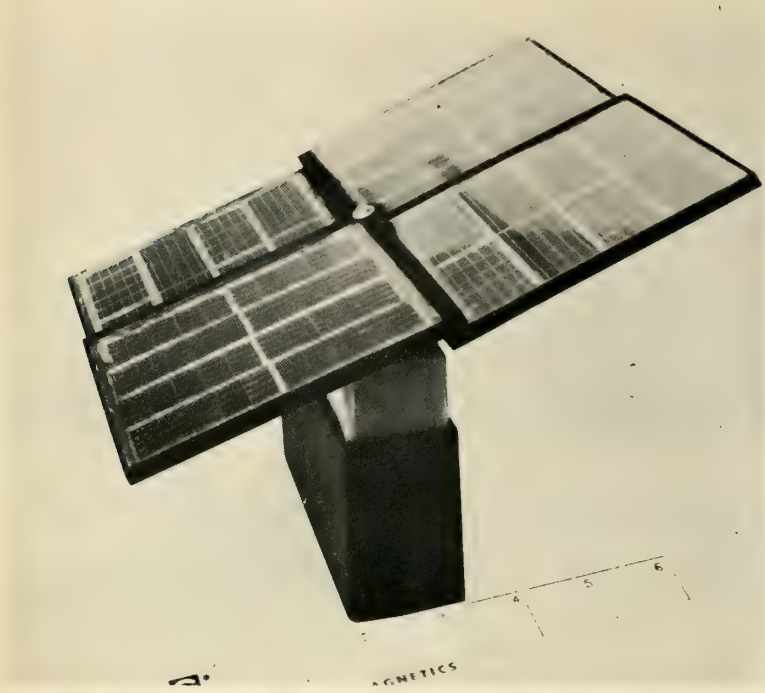
Negotiations are to be conducted with Dunlap and Associates, Inc., for further research on the critical manning problem of the *Polaris* fleet under Contract Nonr-4344(00)(X). RFP not available; for information only.

Contract Management Office
Space Test Operations
Los Angeles, California 90045

RFP issued to Philco Corp., Western Development Laboratories, Palo Alto, Calif., for advance planning and orbital support planning effort for satellite control programs. RFP's not available; for information only.

National Aeronautics and Space Administration
Manned Spacecraft Center
Houston, Texas 77058

Negotiations will be conducted with Thompson Ramo Wooldridge, Inc., Space Technology Laboratories, Houston, Tex., for one each image converter camera and accessories. RFP not available; for information only.



New Product of the Week: Modular Solar Cell Array

Gulton Industries, Inc., Engineered Magnetics Div., has available a modular solar array that weighs 1 lb. and measures 8 x 8 in.

The EMSA-101 has an output that can be used to run equipment directly or to charge 12-v batteries. Each individual 4 x 4-in. panel has an output of 16v at 50 ma with open circuit voltage of 22v and short circuit current of 60.5 ma. With panels connected in parallel, output is approximately 16v at 200 ma with 22-v open circuit voltage and 245-ma short circuit current.

Circle No. 151 on Subscriber Service Card

Isolators

Series H44 and H64 isolators, specifically designed to protect electronic equipment from high-amplitude, low-frequence vibrations, have been developed by Barry Controls.

Maximum resonant amplification is held to less than 1.5 with inputs as large as 0.1 in. double amplitude. Resonant frequencies are between 7 and 8 cps. Performance is unaffected by ambient temperatures from —67° to 300° F. The devices meet requirements of MIL-C-172, MIL-E-5400 and MIL-STD-810.

Circle No. 152 on Subscriber Service Card

Telemetry Calibrator

A telemetry calibrator, combining a deviation monitor, signal generator and deviation calibrator, has been developed by Advanced Measurement Instruments, Inc.

The Model 405 FM instrument features a carrier frequency range direct reading from 210 to 270 mc. Calibration accuracy is ±0.25%. The signal generator calibrates the monitor by use of the carrier vanishing method. Accurate audio frequencies required for full-scale carrier vanishing are supplied internally. Deviation accuracy exceeds 1%. Any external frequency can be applied up to 1.5 mc.

Circle No. 153 on Subscriber Service Card

Vacuum System

A general purpose metallurgical vacuum system, able to perform a variety of vacuum and inert atmosphere melting, heat treating or joining operations, has been developed by Vacuum Industries, Inc.

The System VII is designed to be mounted on standard bell jar vacuum evaporator consoles. It consists of a non-magnetic stainless steel, water-jacketed, vacuum chamber, measuring 18 in. in diameter and 20 in. long. Operating at temperatures up to 3,000°C, the system can be used to vacuum heat treat or melt loads with working volumes up to 6 x 6 x 15 in. The unit operates with any pumping systems with a 20-in.-dia. base and is pedestal mounted.

Circle No. 154 on Subscriber Service Card

Portable X-ray Machine

A portable double-focus X-ray machine, rated at 400 kv constant potential at 10 milliamps, is available from the Westinghouse Electric Co.'s X-ray Div.

The "Baltomatic 400" can inspect a variety of metal products—from thin-walled aluminum castings to 4-in.-thick steel weldments. The unit has two focal spot sizes—4 x 4 mm and 1.5 x 1.5 mm. These permit use of both total power output and fine focusing techniques. The X-ray tube, generators and tube housing are combined in a single unit head. A kilovoltage meter and selectors, a milliampere control and an automatic reset timer are mounted on a control panel. Power supply is 220v.

Circle No. 155 on Subscriber Service Card

Electron Beam Gun

A work-accelerated electron beam gun, designed to produce thin metallic and non-metallic films in high vacuum, is available from Materials Research Corp.

The V4-200 is able to achieve temperatures in excess of 3,600°C for controlled evaporating of such refractory materials as tungsten, tantalum, carbon and metallic oxides.

Under the work-acceleration principle, a beam of electrons flows from an emitter to an anode. Upon striking



the material to be deposited, the electrons release their kinetic energy causing heating. Both pedestal and electron beam filaments are replaceable and can be supplied in various materials.

The device is available for use in 12-in., 18-in. and larger belljar systems.

Circle No. 156 on Subscriber Service Card

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This fifth edition of the WORLD SPACE DIRECTORY lists over 17,000 key industry personnel in approximately 4,250 U. S. and foreign missile/space and defense-oriented companies, organizations and government agencies. Over 50% of the listings have been revised and over 400 new companies added to reflect changes in the industry since the last issue was published in March, 1964.

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DC Motor

Copaltronics, Inc., has available a miniature dc motor, capable of producing torque up to 50 oz.-in. The unit measures 1.02 in. in diameter and 3.182 in. in length and operates on voltages from 1 to 50v. Speed range is 50 to 6,000 rpm.

Circle No. 157 on Subscriber Service Card

Magnesium Fiber

Aerospace Products Div. of Johns-Manville has developed a hydrous magnesium fiber for use in reinforced plastic parts subjected to conditions of high temperature, ablation and erosion. The fiber, called TX, has an ultimate resistance of 5,070°F.

The potential of a TX-reinforced plastic system is based on three characteristics of the fiber, the firm says. These are the ultimate temperature resistance, the endothermic reaction undergone during high heat exposure and the insulating qualities of the reinforced system.

The fiber contains approximately 28% of chemically combined water. Under heating conditions (635° to 878°F), approximately 22% of this water is released. Thus, during hyperthermal exposure, the fiber would function partially as a transpiration cooling mechanism within the reinforced part, the firm points out.

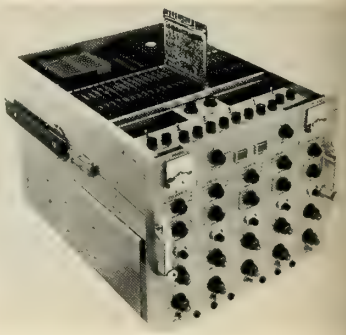
TX-laminated plastics systems on sheet reinforcement have flexual strengths of 15,000 to 18,000 psi and tensile strengths of 9,000 to 11,000 psi. Modulus of elasticity is approximately 2.4 x 10^6 psi.

Circle No. 158 on Subscriber Service Card

Bit Synchronizer

A bit synchronizer and signal conditioner that locks the clock to within ±5 degrees for the entire tracking range has been developed by the Roback Corp.

The device operates on signal-to-noise ratios as high as –10 db and recovers data to within 1 db of the theoretical limit for any desired bit rate from 1 to 1,000,000 bps.



Front-panel controls can select bit rates to within 2% without a counter. Output polarity may be ±6 to ±12v; rise and fall times are less than 100 nanosecs into 1,000 mf and 1,000 ohms. Optional features include a 10-cps to 500 kc six-pole active bessel filter.

Circle No. 159 on Subscriber Service Card

Hermetically Sealed Igniter

A hermetically sealed igniter for use in "quick-fire" applications has been developed by Aerospace Components Div. of Atlas Chemical Industries, Inc.

The 1GN18 contains a glass-to-metal seal at the squib end. The output end of the device is sealed by a beryllium copper disc. Bridge resistance at the ends of the leads is 1.3 ± 0.1 ohm. The device will function in ambient temperatures of —65° to 160°F and can withstand storage temperature of 300°F for 0.5 hr. Firing characteristics for the igniter are: no fire (at 160°F) 0.05 amp for 5 secs. maximum; all fire (at — 65°F) 0.6 amp for 100 ms maximum.

Circle No. 160 on Subscriber Service Card



Circle No. 4 on Subscriber Service Card

new literature

EDP GLOSSARY—Honeywell, Inc., has published a "Glossary of Data Processing and Communications Terms," containing over 3,500 listings. The 85-page publication also includes lists of Honeywell character codes and standard templates and binary extension and octal-decimal conversion tables.

Circle No. 161 on Subscriber Service Card

COMPUTER APPLICATIONS—A booklet called "Applications of Computers to Engineering Problems" has been published by Pastoriza Electronics, Inc. The 20-page booklet is composed of five lectures presenting the anatomy of a computer system and how system elements and variables are modeled by equations and computers. The publication permits the engineer to program such a system for analog and digital analysis and includes notations by which system structures can be communicated to computers.

Circle No. 162 on Subscriber Service Card

TRANSDUCER SYSTEM DESIGN—A paper summarizing the basic design information of a transducer system is available from Statham Instruments, Inc. The "Notes 37" reviews electrical aspects of the transducer signal, but does not consider the electromechanical conversion principle. Sufficient information is presented to permit the instrument engineer to design an optimum transducer system.

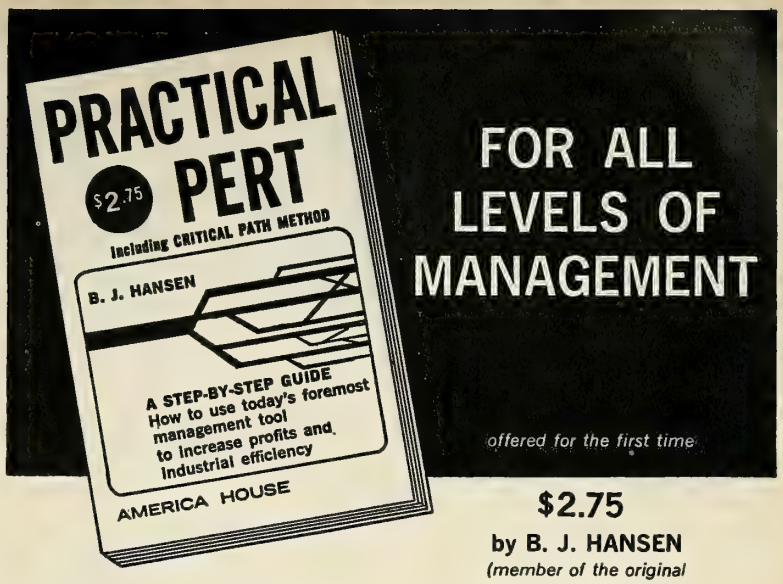
Circle No. 163 on Subscriber Service Card

ACRONYM/ABBREVIATION GLOSSARY—Plenum Press has published a volume of "Space-Age Acronyms and Abbreviations," compiled by Reta C. Moser. The listing contains over 10,000 technical and industrial acronyms with more than 17,000 definitions. The glossary features cross references and a section listing missile, aircraft, ship and communications electronic equipment designating systems. Russian acronyms and abbreviations likely to be encountered in technical translations are included.

Circle No. 164 on Subscriber Service Card

RECTIFIER TEST—Udylite Corp.'s Electro Chem Power Div. has published a guidebook, "Rectifier Theory and Application." The 40-page book is "a distillation of Udylite electrical research over a period of more than 25 years." The illustrated volume includes a study of types of rectifiers with advantages and disadvantages noted, as well as comparison charts showing different rectifying devices evaluated against one another.

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names in the news


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Dr. William F. Ballhaus: Named president of Beckman Instruments, Inc., Fullerton, Calif. He will resign as executive vice president of Northrop Corp. effective Dec. 31, but will remain on the Northrop board of directors.

John E. Verardo: Promoted to vice president of manufacturing for Lundy Electronics & Systems, Inc., Glen Head, N.Y. He will be responsible for direction and planning of all corporate manufacturing activities for Lundy and its subsidiaries.

Thomas G. Jennings: Appointed vice president, manufacturing, at Computer Control Company, Inc., Framingham, Mass. He will direct all manufacturing operations in Framingham and at Electropac, a 3C subsidiary in Peterborough, N.H., for 3C's digital building block products, special purpose digital systems and general purpose computers.

Dr. Roland J. Benjamin: Named manager of the Aerospace Section at Cook Electric Company's Tech-Center Div., Morton Grove, Ill. He was previously the Aerospace section's director of engineering.

Maxwell C. Scott: Named to direct a new division of Sylvania Electric Products, Inc., western operation in Mountain View, Calif. He will direct the Product Assurance Organization in addition to his other duties as special assistant to the vice president and general manager of the western operation.

Henry A. Samulen: Appointed vice president of TRW-Space Technology Labs, Redondo Beach, Calif. He will be in charge of the Electronics Div. Also appointed were **Robert B. Muchmore,** vice president-director of the Physical Research Div., and **James P. Brown,** vice president-director of marketing.

Emmett H. Bradley: Named vice president of Atlantic Research Corp.'s Missile Systems Div., Duarte, Calif.

Marcus F. Cooper: Appointed to the newly created position of Director-Florida Test Center for Douglas Missile & Space Systems Div. at the Eastern Test Range, Cape Kennedy, Fla. He was formerly a major general in the U.S. Air Force.

Ira W. Kane: Appointed manager of military ground systems sales, Philco Corp.'s Western Development Labs Div., Palo Alto, Calif. He was formerly manager of telemetry, tracking and control sales.

Air Reduction Co., Inc., New York City, has announced major organizational changes. **John A. Hill,** formerly president, elected chairman of the board of directors and continues as chief executive officer. **George S. Dillon,** formerly executive vice president, was elected president and remains chief operating officer. **Charles S. Munson,** previously board chairman, was elected chairman of the executive committee.

Byron K. Boettcher: Appointed a vice president of Avco Corporation's Defense and Industrial Products Group in charge of the Eastern Regional Office to be headquartered in Dayton, Ohio.

Frank W. Lehan: Elected vice president-advanced systems, of Aerojet-General Corp., Glendale, Calif. He is also president of Space-General Corp., an Aerojet subsidiary.

Roger W. Walker: Appointed program development manager of Cornell Aeronautical Laboratory, Buffalo, N.Y.

Five staff members of Baird-Atomic, Inc., Cambridge, Mass., have been elected vice presidents, continuing in the same areas of responsibility as held previous to their promotions. The new officers are the following: **I. D'Arcy Brent,** vice president in charge of operations; **John M. Dempsey, Jr.,** vice president in charge of marketing; **Herman Glasser,** president of Baird-Atomic's wholly-owned subsidiary, Atomic Accessories, Inc., now vice president of parent company; **William G. Langton,** vice president in charge of science and engineering; and **David A. Low,** vice president, industrial relations, with responsibility for plant facilities and community relations.

Charles L. Davis: Elected to the board of directors of Honeywell, Inc., Minneapolis. He is also vice president in charge of the military products group. Elected to the board at the same time was **Walter W. Finke,** vice president of the company and president of its electronic data processing division.

—when and where

DECEMBER

131st Annual Meeting, American Association for the Advancement of Science. Montreal, Canada, Dec. 26-31.

JANUARY

11th National Symposium on Reliability and Quality Control, sponsored by the American Society for Quality Control and the Institute of Electrical and Electronics Engineers, Fountainebleau Hotel, Miami Beach, Jan. 12-14.

1965 Government-Industry Forum, sponsored by the National Electrical Manufacturers Assn., New Orleans, Jan. 18-19.

International Symposium on Solar Radiation, sponsored by the American Society for Testing and Materials and the Institute of Environmental Sciences, International Hotel, Los Angeles, Jan. 18-21.

Conference on Quantitative Analysis and Evaluation for Production Activities, sponsored by Purdue University, Purdue University, Lafayette, Ind., Jan. 20-22.

Winter Meeting of the National Society of Professional Engineers, Jung Hotel, New Orleans, Jan. 20-23.

National Symposium on Hydrocarbon Analysis, sponsored by the American Society for Testing and Materials, Sheraton-Lincoln Hotel, Houston, Jan. 22-23.

Symposium on Fundamental Phenomena in the Materials Sciences, sponsored by the Ilikon Corp., Sheraton Plaza Hotel, Boston, Jan. 25-26.

Joint Annual Meeting of the American Mathematical Society and the Mathematical Association of America, University of Colorado, Denver, Jan. 25-30.

FEBRUARY

Reinforced Plastics Division Conference, sponsored by the Society of Plastics Industry, Edgewater Beach Hotel, Chicago, Feb. 2-4.

Winter Convention on Military Electronics, sponsored by the Institute of Electrical and Electronics Engineers, Ambassador Hotel, Los Angeles, Feb. 3-5.

Unmanned Exploration of the Solar System, sponsored by the American Astronautical Society, the American Astronomical Society, American Geophysical Union, American Institute of Biological Sciences, Institute of Electrical and Electronics Engineers, and the American Institute of Aeronautics and Astronautics, Denver Hilton Hotel, Denver, Feb. 8-10.

Spring Meeting of the American Society for Testing and Materials, Statler-Hilton Hotel, Cleveland, Feb. 8-12.

1965 Electrical and Electronic Trade Show, sponsored by the Electrical Representatives Club and the Electronic Representatives Assn., Denver Auditorium Arena, Denver, Feb. 15-17.

Sixth Annual West Coast Reliability Symposium sponsored by the American Society for Quality Control, Los Angeles Section, and the University of California at Los Angeles, Engineering Dept., UCLA Campus, Moore Hall, Los Angeles, Feb. 20.

MARCH

Symposium on High Speed Testing, sponsored by the Massachusetts Institute of Technology, and Brooklyn Polytechnic Institute, Sheraton Plaza Hotel, Boston, Mar. 8-9.

Aviation and Space Conference, sponsored by the American Society of Mechanical Engineers, Statler Hotel, Los Angeles, Mar. 14-18.

International Convention of the Institute of Electrical and Electronic Engineers, New York Hilton Hotel and New York Coliseum, New York City, Mar. 22-25.

Symposium on Thermophysical Properties, sponsored by the American Society of Mechanical Engineers, Purdue University, Lafayette, Ind., Mar. 22-26.

Spring National Convention of the Society for Nondestructive Testing, Los Angeles, Mar. 22-26.

Optical Society of America Meeting, Statler-Hilton Hotel, Dallas, Mar. 31-Apr. 2.

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Letter From the Editor

BEFORE UNDERTAKING the annual review on this page of the events of the year, we glanced back a year to see how things looked to us in December of 1963.

We found we had noted then that one of the most significant long-range decisions of the Administration had been made in the closing days of the year—the decision to go ahead with the *Manned Orbiting Laboratory* program.

As reported on p. 12 of this issue, that decision has just been made again. We consider it just as important and just as significant but are somehow haunted by a feeling that a year has been lost, a year which can never be recovered.

We will repeat what we said in December, 1963:

"The long years of arguing for a manned military space role have come to a close. The opportunity to prove that such a mission is vital and necessary is to be given. There undoubtedly will be future disputes about the size and nature of the military man's activities in space. But a beginning has been made. As the passage of years places the events of 1963 in perspective, we believe this will emerge as the most important single industry development of this year."

We did not expect to be repeating the same prophecy regarding 1964. But aside from that, the sentiment remains valid. We hope we do not have to repeat it next year. The time has come to go to work.

The year of 1964 has been one of preparation in regard to the manned spaceflight program. As a result, front-page headlines for the space program were not as much in evidence. Despite this, a review of the year shows considerable evidence of solid achievement.

The program for development of big solid boosters, still on an up-hill grade, nevertheless marked up a number of significant milestones. Lockheed fired the first 156-in. solid on May 28, repeating the success with the same casing on Sept. 30. In that same month of May, Thiokol dedicated its big new solids facility at Horse Pen Bluff, Ga., and Aerojet-General opened its new solids processing plant in Dade County, Fla. United Technology proved out the 120-in. booster for the *Titan III* during the year. Thiokol touched off the first static firing of its segmented 156-in. on Dec. 12. We can anticipate further growth in the solids program as the big boosters prove out their capabilities in the months ahead. The atmosphere for solids has never been a particularly favorable one, but we expect this to change in the face of the inevitable successes which will be recorded.

Despite the absence of manned flights, a number of U.S. firsts were recorded in space during 1964. Without question, the most spectacular accomplishment of the year was the photographing of the lunar surface by *Ranger VII*, with a television relay of 4,316 photographs to Earth. These are proving invaluable both to astronomers and to technicians working on the *Apollo* manned lunar landing program.

The Soviet Union, unable to match the U.S. in either lunar or planetary probes, came up with a spectacular of its own when it launched the three-man *Voskhod* spacecraft on Oct. 12 for a 24-hr. flight. This was the first Russian manned space flight since June, 1963, and it served notice that the Soviets are maintaining their lead in this field.

There has been no U.S. manned flight since the final *Mercury* flight in May, 1963, and the first *Gemini* manned flight will not take place until next spring at the earliest. The *Gemini* program, however, did get under way in 1964 with a successful unmanned shot in April which proved out the combination of the McDonnell capsule and the *Titan II* launch vehicle.

The U.S. scored with the first test flight of an ion engine in space with the launch of *SERT I* (*Space Electric Rocket Test*) from Wallops Island, the first television relay from a satellite in stationary orbit accomplished with *Syncom III*, the high quality of weather photos from *Nimbus I*, the unprecedented plotting accuracy established with the Army's *SECOR* geodetic satellite and the unbroken chain of test successes with the *Saturn I* space booster.

The space year closed with *Mariner IV* on an extremely accurate course for Mars and its Soviet competitor, *Zond II*, close behind. The final chapter in this story must wait until rendezvous with the red planet in 1965.

THE PICTURE ELSEWHERE in Dept. of Defense missile and space programs was less rosy as the year closed, although Secretary of Defense Robert S. McNamara's declaration of support for *MOL* was his strongest stand to date in favor of the manned military space program, auguring well for the future.

SAMOS continues its successful and unpublicized surveillance of inaccessible areas of the world such as China and the Soviet Union—not only providing a tip-off to the first Chinese atomic test but bringing a suggestion from Mr. Khrushchev that it was a much more desirable device than airplanes for keeping watch on Cuba. Which incidentally brings to mind two further events of significance to the industry during the year: President Johnson kept his job; Mr. Khrushchev lost his.

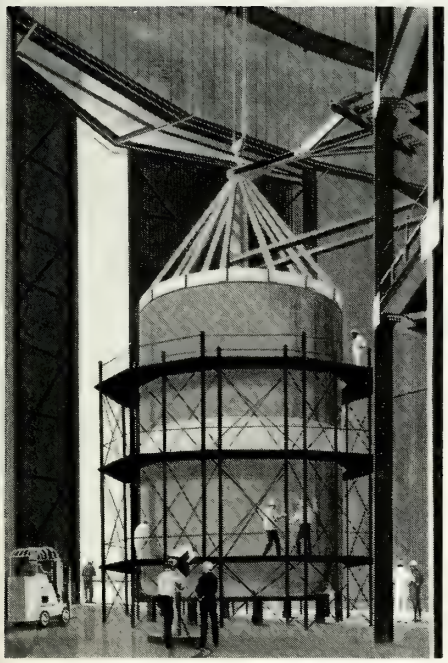
The *Mobile Mid-Range Ballistic Missile* was allowed to die a quiet death, the *Low-Altitude Supersonic Vehicle (LASV)* and its *Pluto* nuclear ramjet engine died a less quiet death—and Mr. McNamara vowed to die a thousand deaths before being caught at lunch with a contractor.

Shillelagh and *Redeye* moved into production and the American Institute of Aeronautics and Astronautics held its first annual meeting. DOD announced development of two anti-satellite weapon systems but decided its long effort to find common cause with Communications Satellite Corp. was a failure.

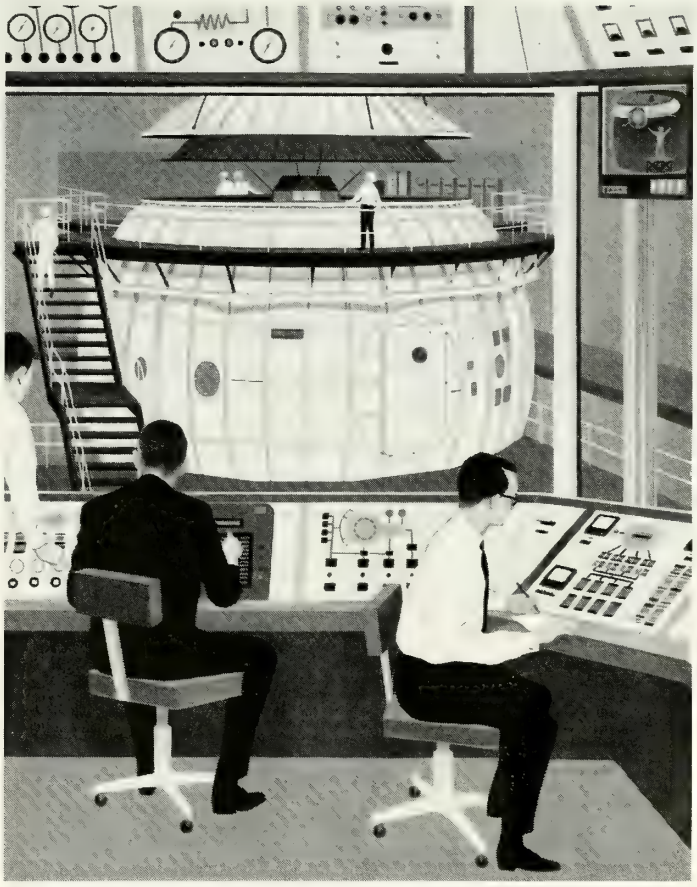
There can be no question that 1964 was an active year for this industry, with 1965 promising to be even more so. Nor can there be any question about our traditional wish from MISSILES AND ROCKETS to all of you: Merry Christmas and a happy, peaceful New Year.

William J. Coughlin

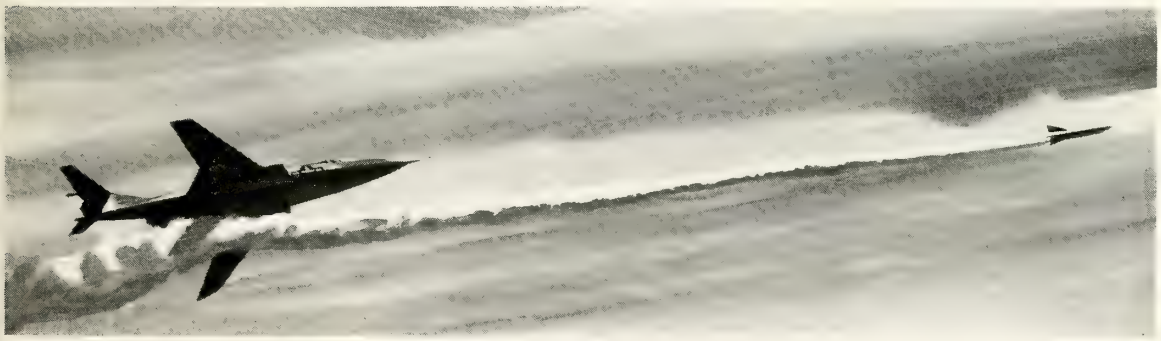
LOOK WHAT DOUGLAS IS DOING NOW!



SATURN S-IVB stages are being completed in the Douglas Space Systems Center. Here, a unique central control system in the Structures Laboratory allows complex structural test programs to be conducted while others are being prepared.



HIGH VACUUM SPHERE with 30,000 cu. ft. capacity in the Space Simulator Building creates the vacuum equivalent of a 500 mile earth orbit. It will be man-rated, and can accommodate full-size spacecraft up to 30 feet long.



TO KEEP ON TARGET with new, more effective missiles, Douglas is exploring advanced techniques in relation to present tactical and strategic military problems. It is drawing on experience gained in producing more than 40,000 missiles relating to air-to-air, air-to-ground, ground-to-air and ground-to-ground missions.

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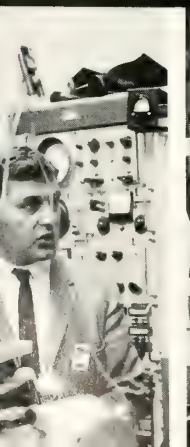


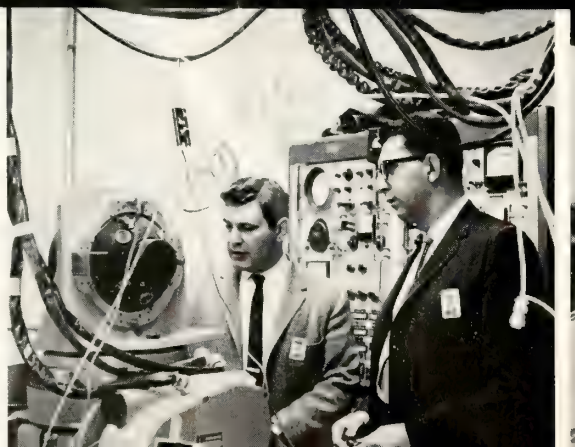
Project Fishbowl:

13 weeks from go-ahead to field delivery—
Tight management control at Avco/RAD. Air Force assignment to Avco/RAD: design and produce flight-test vehicles for Project Fishbowl. Ninety days after we received the go-ahead, hardware was delivered to Johnson Island. This fast reaction capability is built into Avco/RAD's systems management organization. Our project offices keep rigid control over project tasks, costs, and schedules . . . so that they can give immediate and knowledgeable response to the customer. The line departments perform the actual program tasks, bringing to bear experienced scientists and engineers in all relevant disciplines. This overall, flexible management system ties together the in-house functions of research, design, testing, and manufacturing. *That's what we mean when we say: Avco/RAD is an integrated research and development organization.*

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